PLEISTOCENE NON-MARINE MOLLUSCA OF NORTHEASTERN WISCONSIN

EDWARD CARL ROY, Jr.[1]

Department of Geology, The Ohio State University
After September 1, Shell Oil Company, Corpus Christi, Texas

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ILLUSTRATIONS

ABSTRACT

Thirty species of Pleistocene non-marine Mollusca occurred in the 5 extinct lakes studied in northeastern Wisconsin. Of these, 5 are fresh water pelecypods, 18 are fresh water gastropods, and 7 are terrestrial gastropods. The mollusks were studied both quantitatively and qualitatively. Each deposit was sampled at 2-inch intervals except the Mountain deposit which was sampled at 8-inch intervals. All the deposits are located on drift of either the Cary or the Valders substage of the Wisconsin glaciation. Three of the deposits are located along the north-south trending Mountain morainal system, one is to the west of it, and one is to the east.

The Mollusca of each deposit were studied primarily to reconstruct the former environment in which they lived. The species that occurred most abundantly are considered to be native to the habitat in which they lived. Those that are less common are probably intruders from a nearby environment, and those that are rare are intruders carried in by some outside agent. Changes in the percentages of the species in a deposit were quite common. These changes reflect changes in the environment of the lake at the site of the sampled section. The number of shells in each collection varied with lithology; they were more abundant in the marl than in the peat.

The species occurring most commonly are Pisidium casertanum, Valvata tricarinata, Amnicola limosa, Amnicola lustrica, Fossaria obrussa decampi, and Gyraulus parvus. All of these live in shallow water with some vegetation. Variations in the percentages of the above species reflect slight changes in the habitat. Amnicola limosa, A. lustrica, and G. parvus favor a habitat with vegetation, and F. obrussa decampi favors a very shallow water habitat.

Each of the deposits was formerly a small lake or pond which came into existence shortly after the area was free of ice. They were all lakes of shallow water with a relatively soft bottom. The vegetation varied from moderate to dense. The water in the lakes was neutral to slightly alkaline, ranging in pH from 7 to 8. The changes of environment reflected by the mollusks were generally changes in depth of water. The water was probably cooler then than now as indicated by the presence of Helisoma anceps striatum, a subspecies believed to live only in cold water. The similarity of the faunas from the 5 extinct lakes to a living fauna in northern Minnesota indicates that the climate in northern Wisconsin in Late Wisconsin time was like that of northern Minnesota today.

A few notable mollusks were absent in the 5 deposits, but are known to live in northeastern Wisconsin today. They are the Naiad pelecypods, Bulimnea megasoma, Acella haldemani, and Helisoma trivolvis. These species probably migrated to northeastern Wisconsin at a later time than the species that occurred in the 5 lakes, and at a time after the lakes had become extinct.

INTRODUCTION

Purpose of Investigation

The primary purpose of this investigation is to make a quantitative and qualitative study of the non-marine molluscan fauna of five Late Wisconsin deposits in northeastern Wisconsin. The former environment of each of the five deposits was reconstructed from the data obtained. Special attention was given to quantitative changes in species that might reflect changes in lithology or environment. This type of investigation gives information on which species were first to repopulate northeastern Wisconsin after the last glaciation. This helps in determining the rate and routes of migration of non-marine Mollusca after deglaciation. The information contained in this report, along with that from similar investigations, will help establish the significance of index fossils for the Pleistocene.

Location of Deposits

The five deposits studied are located in the northeastern part of the state of Wisconsin. The area is located between 44 degrees 20 minutes and 45 degrees 45 minutes north latitude and 87 degrees 45 minutes and 89 degrees 5 minutes west longitude. The White Lake deposit is located on the eastern edge of the village of White Lake, Langlade County, SW 1/4, NE 1/4, Sec. 21, T. 31 N., R. 14 E. The Spur Lake deposit is located about 4 miles northwest of Dunbar, Marinette County, NW 1/4, NW 1/4, Sec. 3, T. 37 N., R. 18 E. The Mountain deposit is in Oconto County, about 2.5 miles south of the village of Mountain, in the SE 1/4, SE 1/4, Sec. 22, T. 31 N., R. 16 E. The Waupaca deposit is located 2.5 miles north of the town of Waupaca, Waupaca County, SW 1/4, NE 1/4, Sec. 8, T. 22 N., R. 12 E. The Harmony deposit is located in Marinette County about 1.5 miles south of the village of Harmony, SW 1/4, NW 1/4, Sec. 15, T. 30 N., R. 22 E.

Method of Investigation

In this investigation five marl deposits were selected for study from approximately 15 that were examined in the field. The five were selected on the basis of geographic location, accessibility of the marl, and general fossil content. Each individual deposit was mapped by menas of pace and compass and information from air photos. The section to be collected was selected on the basis of the maximum thickness of marl that could be obtained by digging a pit into the marl.

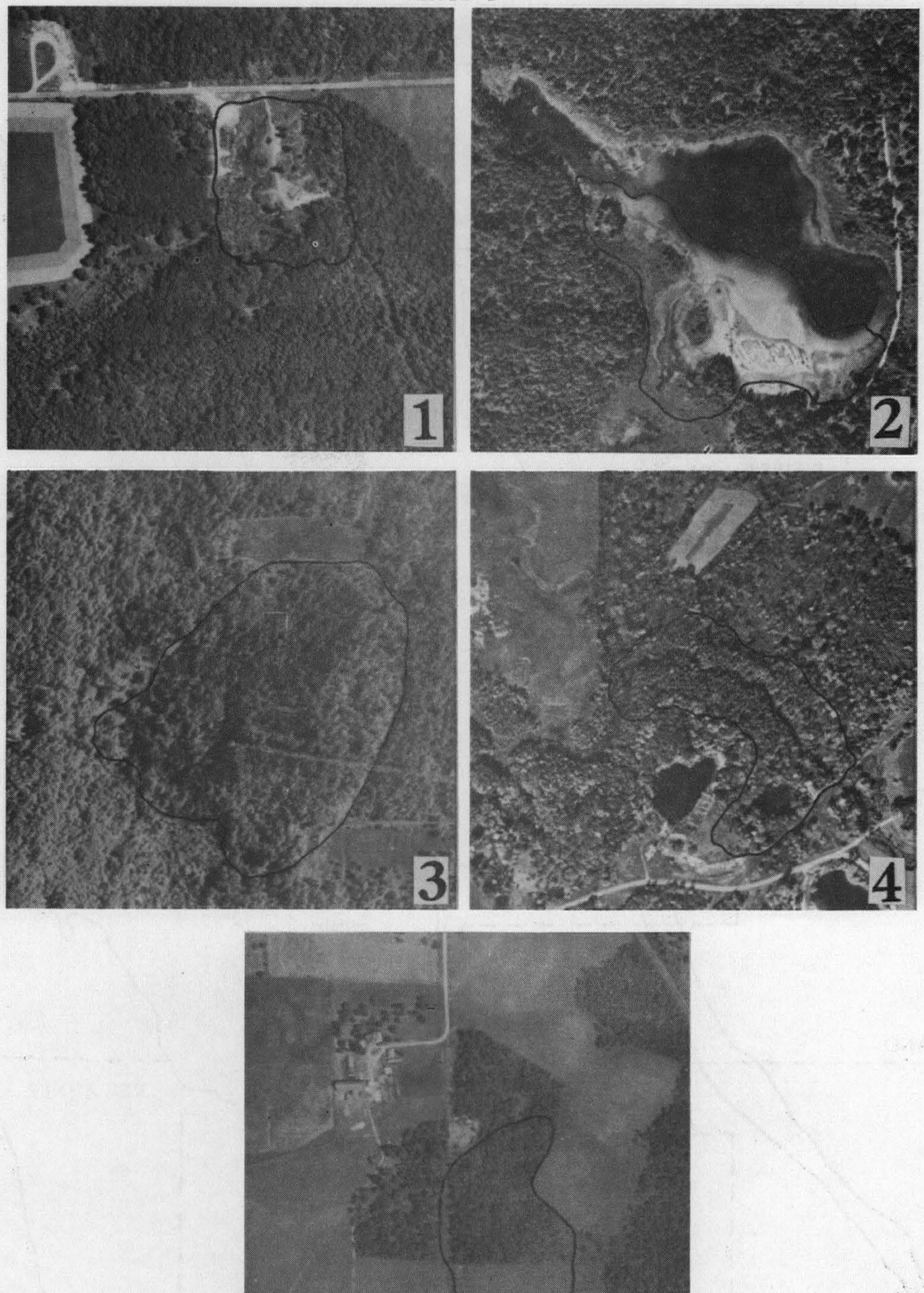
A pit was dug at a site from the top of the deposit to the base. Its dimensions were approximately 4 feet long and 3 feet wide. The section was collected at two-inch intervals in samples of 12 X 12 X 2 inches. Each collection was labeled and placed in a plastic bag which was sealed to preserve the moisture of the sample. The samples were then taken to the laboratory. The only variation from this method was at the Mountain deposit where the collections were made with a post-hole auger of 8-inch diameter and taken at 8-inch intervals.

In the laboratory the samples were soaked in water for approximately 24 hours before being sieved. They were then washed through sieves of 10, 20, and 30 mesh and allowed to dry. The dried samples were placed in containes and properly labeled. The amount of the sample that was sieved was between 1000 and 4000 milliliters, depending on the number of shells that appeared to be in the sample.

The dried samples contained the shells, plus a considerable amount of other matter that could not be washed through the sieves. The 10 and 20 mesh portions were combined and the shells were picked out of the residue material by hand. The 30 mesh portion was stored for further study. If the residue material contained a great many shells, it was split by means of a sample-splitter, into halves, quarters, or occasionally into eighths.

(Text continued on p. 11)

PLATE I



AERIAL PHOTOGRAPHS OF THE FIVE NORTHEASTERN WISCONSIN DEPOSITS.
Fig. 1. White Lake; Fig. 2. Spur Lake; Fig. 3. Mountain;
Fig. 4. Waupaca; Fig. 5. Harmony.
SCALE: 1 inch to 660 feet.

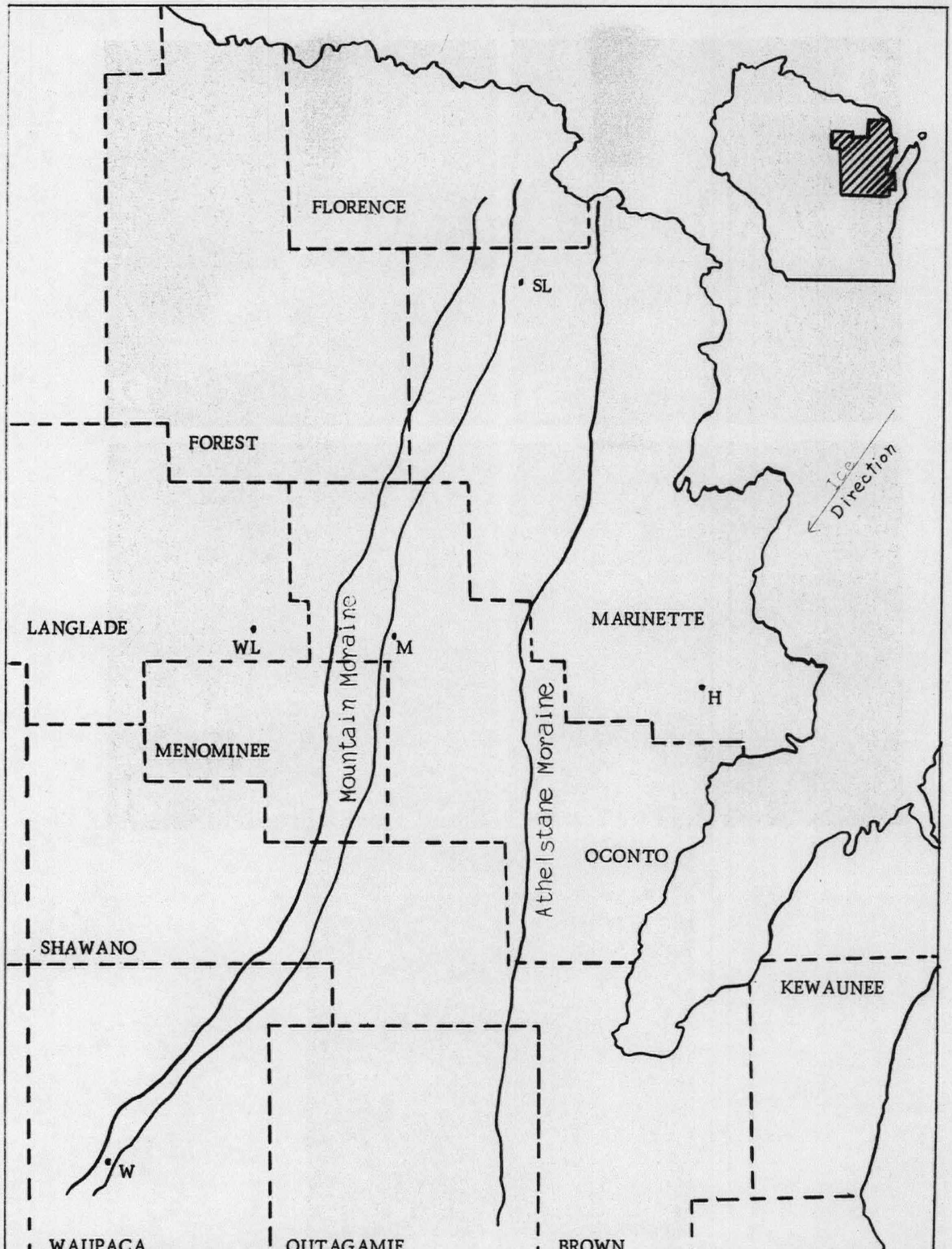


Figure 1. Sketch Map of the Area of Northeastern Wisconsin covered by this Report; Showing Location of Deposits and Principal Moraines. WL - White Lake Deposit; SL - Spur Lake Deposit; M - Mountain Deposit; W - Waupaca Deposit; H - Harmony Deposit.

The selected portion of the residue was then picked in order to obtain a minimum of 1000 shells. From the shells that were picked, one thousand were counted at random and identified to species. The shells of each species were then counted and represented as a percent of the total population in each collection.

The comparison among species of a given collection as well as the comparison from collection to collection is shown both in table form and graphically. The relative number of shells in each collection was determined and this is shown as the number of shells per 1000 milliliters of sediment.

Acknowledgements

I wish to express my sincere gratitude to my adviser, Prof. Aurèle La Rocque, for his help during the field work, laboratory preparation and identification, and writing of this report. I thank my wife, Carol, for her help in the laboratory preparation of the specimens and for typing the first draft; and my brother, Bob, who was my field assistant for the summer of 1962. Thanks are also due to the graduate and undergraduate students who helped me in various ways in the laboratory. I acknowledge gratefully the following financial aid; two grants from the Bownocker Fund of the Department of Geology, Ohio State University, used for field work; the National Science Foundation, Project Number 1642, for support during the summer of 1963, and a grant from the Friends of Orton Hall Fund that was used for the illustrations appearing in this report.

PLEISTOCENE GEOLOGY OF NORTHEASTERN WISCONSIN

General Statement

The topography and surficial deposits of the area of northeastern Wisconsin covered by this paper are almost entirely of glacial origin. These features and deposits were formed during the Cary and Valders substages of the Wisconsin stage of glaciation. The principal topographic features are recessional moraines and pitted outwash plains, and these deposits are composed of either till or stratified drift.

The Cary till which covers the western part of the area is gray with many large rock fragments commonly in a sandy matrix (Thwaites, 1953, p. 15). This till forms well defined recessional moraines which mark the former perimeter of the Green Bay lobe. The most prominent in the area is the Mountain morainal system (see Fig. 1) which trends approximately north-south, and marks a halt in the retreat of the Cary ice. From this position the ice retreated to the east to the position of the Athelstane morainal system in the eastern part of the area. While the ice was at this position an extensive outwash plain was deposited to the west (Thwaites, 1943, p. 133). Upon further retreat the Cary ice disappeared from northestern Wisconsin. It is very probable that the ice retreated far enough to open the Straits of Mackinac (Thwaites, 1943, p. 136). With the retreat of the Cary ice, northeastern Wisconsin was blanketed with glacial outwash and lake clays which were deposited in ice marginal lakes.

Following the Cary ice retreat, a forest grew over much of northeastern Wisconsin as evidenced by the wood and plant material between the Cary and Valders drifts. Wilson (1932, p. 34) states that "the interval in which the forest bed developed was at least 82 years in length, as shown by the growth rings of the oldest log ..." F.C. Baker identified seven species of mollusks from the forest bed and was able to recognize three distinct levels. The lowest contained *Fossaria dalli*, *Pupilla muscorum*, and *Succinea avara*. In the middle level were shells of the land snails *Succinea avara* and *Vertigo ventricosa*. The upper level contained three species of aquatic mollusks, *Gyraulus circumstriatus*,

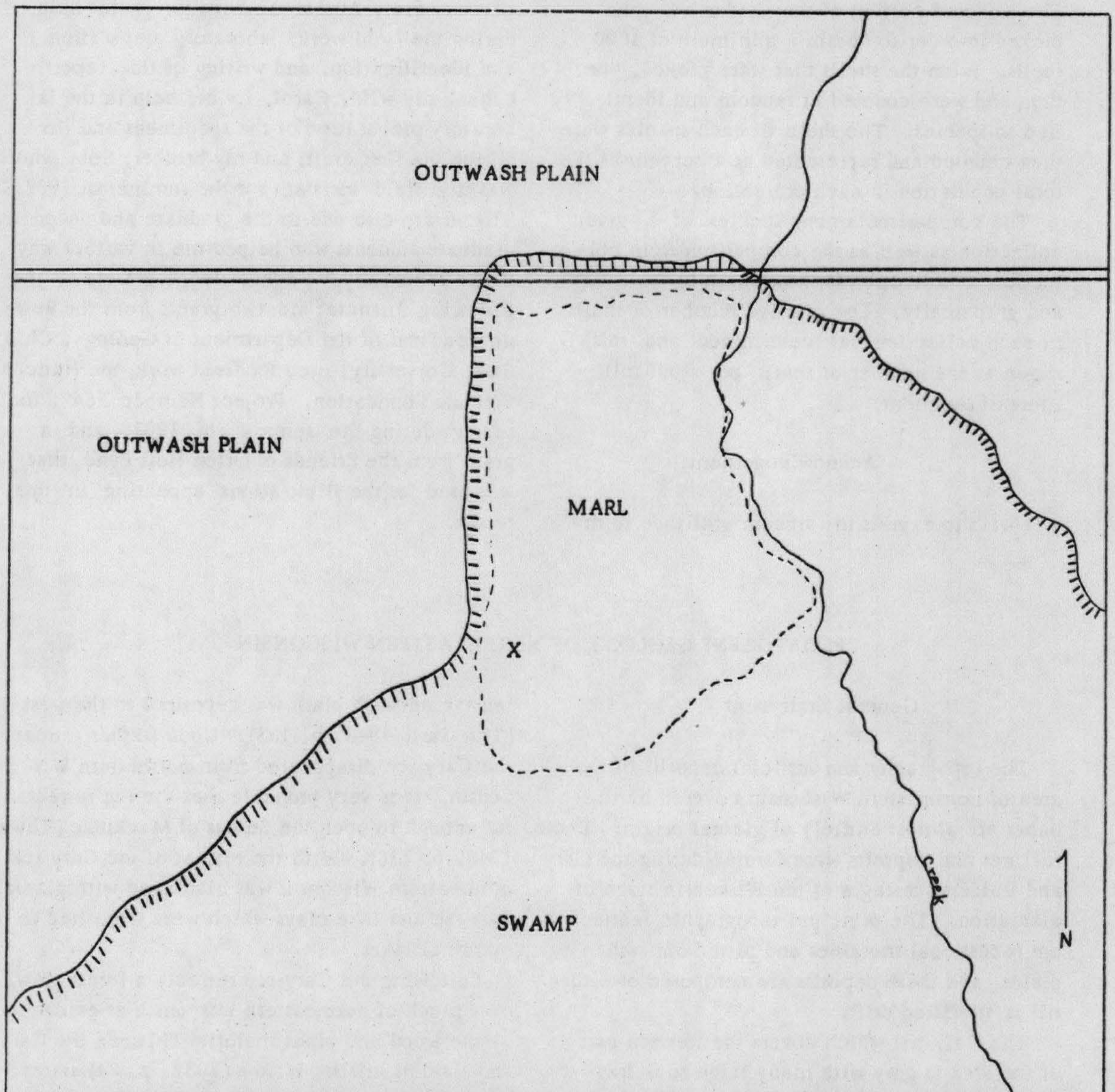


FIGURE 2. Sketch Map of the White Lake Deposit. X = Sampled Section.
Scale: 1 inch to 365 feet

Fossaria parva, and *Pisidium* sp., indicating that the forest bed was probably flooded as a result of the advance of the Valders ice (Wilson, 1932, pp. 39-40). The study of the plants and animals of the Two Creeks forest bed by Wilson and Baker led to the conclusion that the climate was like that of northern Minnesota today.

Many samples of peat and wood from the Two Creeks forest bed have been dated by the radiocarbon method. Broecker and Farrand (1963, p. 801) have determined the age of the forest bed to be 11,850 ± 100 years before present.

The last glacial stage in northeastern Wisconsin was initiated by the advance of the Valders ice. This ice covered approximately two-thirds of the area at its maximum extent. The Valders drift can be distinguished from the underlying Cary drift by its red color and much finer texture, whereas the Cary is gray in color and sandy in texture (Murray, 1953, p. 141). The drift of the Valders glaciation is relatively thin, indicating a short period of ice occupancy in northeastern Wisconsin. Because of the thinness of the drift and the fact that it did not construct any major topographic features, the exact perimeter of the Valders maximum is difficult to trace. The melting of the Valders ice marks the final retreat of the glaciers from northeastern Wisconsin. Thwaites (1943, p. 137) considers that the absence of any recognizable moraines within the Valders area, combined with the meandering courses of many eskers, indicates that the ice became stagnant immediately upon reaching its maximum.

The extinct lakes studied rest directly on glacial drift of either the Cary or the Valders substage. Three are aligned along the Mountain morainal system, one is to the west of it, and one is to the east (see Fig. 1). The northernmost deposit is the Spur Lake deposit. The marl is located in a shrinking glacial lake which occupies a shallow depression in an area of glacial outwash. This deposit is the only one associated with a natural body of water at present. To the south of Spur Lake is the Mountain deposit. Here the marl was deposited in a body of water bounded on the west by a high morainal ridge and on the east by a gently rising slope of land covered by glacial outwash. Along this same morainal ridge, to the south in Waupaca County, the Waupaca deposit is located. The marl was deposited in a pond that developed in the low places of pitted outwash. The White Lake deposit is located to the west of the Mountain moraine and probably represents the oldest deposit studied. The former body of water may have been a ponded area of a stream which cut through a glacial outwash plain. The deposit to the east of the Mountain moraine, the Harmony deposit, is probably the youngest. It was formed in a lake that developed in a shallow depression in Valders ground moraine.

White Lake Deposit

The White Lake deposit (see Fig. 2) formed in a channel that had been cut into a pitted outwash plain. It appears that a stream cut the channel and that marl was deposited in a small ponded area of the stream. The marl deposit is surrounded on the east, west, and north by a sandy bank which is approximately 15 feet high. The top of the bank is flat and is concordant with the general surface of this area. To the south, the deposit is not bounded by this bank but grades into a very swampy area in which the muck and peat are over 8 feet thick. The area of the marl and swamp is forested but some of it has been cleared to allow for excavation of marl. A small stream now drains the area from north to south. The sand forming the bank is medium- to coarse-grained and tan to reddish tan in color. It appears to be somewhat stratified. The general character of the sediment and its fairly extensive flat surface would seem to indicate that it is a glacial outwash deposit. It was mapped by Thwaites (1943, pl. 10) as Cary outwash. The outwash is between two well-defined Cary recessional moraines and was probably deposited when the ice stood at the position of the Mountain moraine a few miles to the east. This would make the outwash Cary in age and the lake some time after the Cary retreat. There is no evidence of any drift from the Valders glaciation, and it is

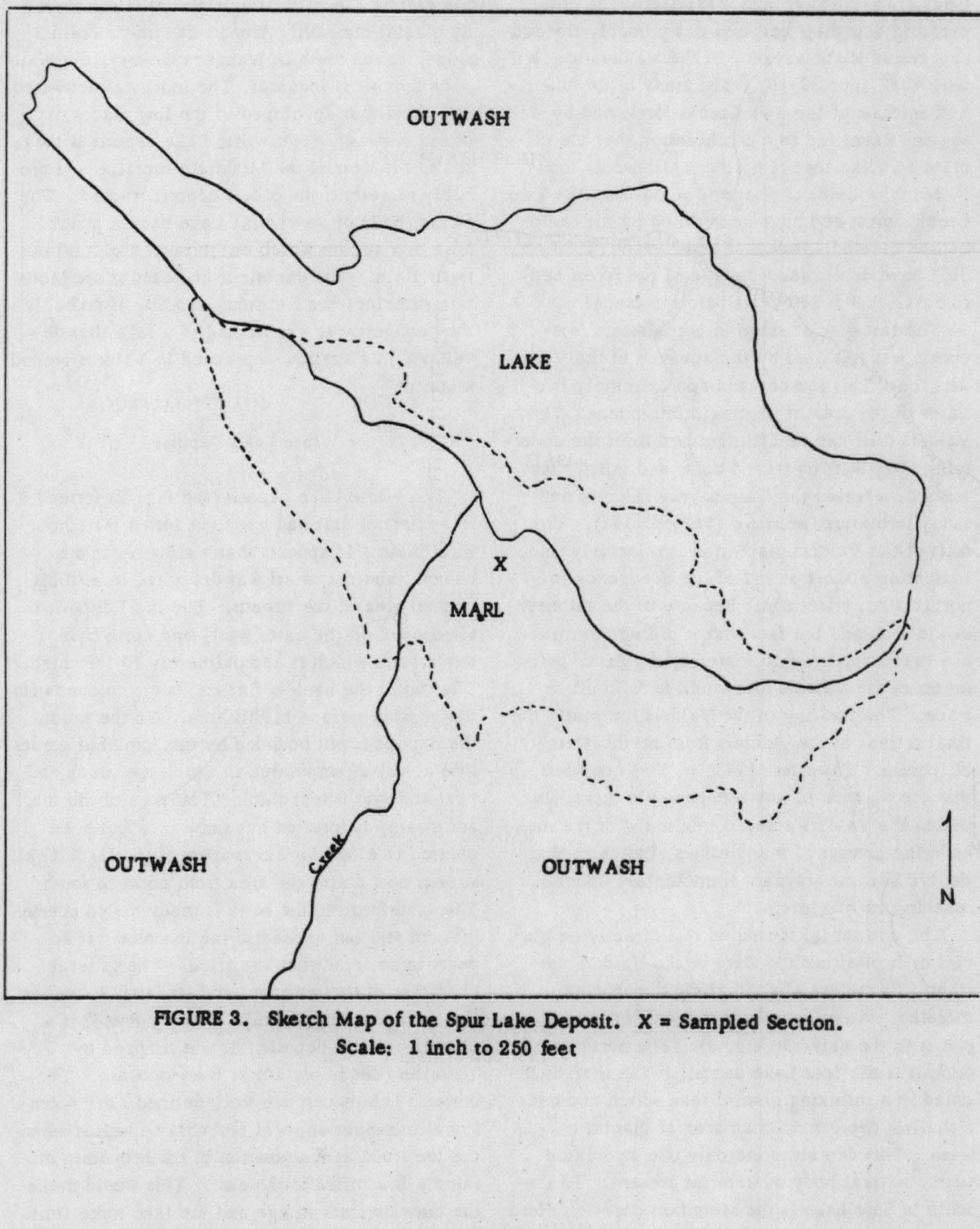


FIGURE 3. Sketch Map of the Spur Lake Deposit. X = Sampled Section.
Scale: 1 inch to 250 feet

possible that the lake was in existence at the time of the Valders glaciation.

The White Lake deposit is an extinct lake or pond accumulation composed principally of marl and peat. The marl makes up most of the section and in places is between 6 and 7 feet thick. The lake was formed on a medium- to coarse-grained sand base. The first accumulation of sediment was approximately 8 inches of fairly well compacted peat. Above this are a few inches of clayey peat in which the first shells appear; this in turn grades into a marly peat and then a peaty marl. Marl with an abundance of clay and plant material makes up most of the remaining section except for a few units of peat and one unit of sand 3 inches thick about 24 inches from the base. The sand is unfossiliferous and contains small lumps of clayey peat which contain shells. The top 14 inches is composed mostly of organic plant remains.

The marl is everywhere covered by at least 8 inches of black organic muck. The much cover is thinnest on the northern side of the deposit averaging about 8 - 12 inches. To the south it becomes thicker and the last trace of marl was located under a cover of 7 feet of muck. The muck continues to thicken to the south.

Stratigraphic Section

Coll.	Unit		Inches
1-4	15	Muck, black, clayey, abundant plant matter, unfossiliferous ...	8
5	14	Marl, dark brown, very platy, abundant plant matter, fossiliferous ...	2
6-7	13	Peat, dark brown to black, some layers of dark greenish material, calcareous, platy, fossiliferous ..	4
8-19	12	Marl, gray-brown, dries gray, fine-grained, very clayey, abundant plant matter, fossiliferous...	24
20	11	Marl, gray-brown, peaty, very clayey, fossiliferous	1
21-23	10	Marl, brownish gray, fine-grained, clayey, abundant plant matter, sandy near base, fossiliferous....................	6
24	9	Sand, gray, medium-grained, few pebbles, with small patches of peaty clay which contain shells.	3
25	8	Peat, dark brown to black, contains large plant fragments, fossiliferous	2
26	7	Marl, gray-brown, fine-grained, peaty, clayey, fossiliferous..	2
27	6	Peat, dark brown to black, calcareous, clayey, fossiliferous.	2
28	5	Marl, brown to dark brown, peaty, clayey, fossiliferous	2
29-30	4	Marl, tan, fine-grained, clayey, abundant plant matter, fossiliferous	4
31	3	Marl, gray-brown, peaty, clayey, fossiliferous	2
32	2	Peat, dark brown, clayey, calcareous, fossiliferous	2
33-36	1	Peat, dark brown, clayey, compacted, unfossiliferous	8
		TOTAL	112

Spur Lake Deposit

The Spur Lake deposit (Fig. 3) is the only deposit sampled in which a lake is now present. Water occupies about 80 percent of what was once a larger lake. The only definite trace of marl at this site is on the southeastern side of the lake. About half of the marl is exposed on dry land and the other half is still under water.

The area immediately surrounding the lake is relatively flat and is composed of medium- to coarse-grained reddish tan sand, characteristic of an outwash deposit. Thwaites (1943, p. 10) has mapped the area as Cary outwash. It probably formed when the ice stood at the eastern edge of the Mountain morainal system or farther to the east at the Athelstane moraine. The original lake most likely formed in a depression in the outwash or as a direct result of the melting of an ice-block which had been buried by the outwash.

The marl ranges in depth from a few inches at the edge of the deposit to 6 to 7 feet at the maximum. The marl is quite homogeneous throughout its vertical section and all was described as one unit. The top 6 inches, however, had some sand. The marl is fine-grained, gray, and the amount of plant matter is fairly high and remains constant throughout. Only a three-foot section of marl could be sampled here because of the lake level.

Stratigraphic Section

The Spur Lake deposit can all be included in one unit: Marl, light-tan to tan, fine-grained, dries gray, contains plant matter which remains constant throughout the section, very little clay, fossiliferous .... 63 inches.

Only the top 36 inches were sampled. The marl rests on a base of fine- to medium-grained tan sand.

Mountain Deposit

The Mountain deposit (fig. 4) represents an unusual situation in which a small pond or lake was formed in a hollow between a high morainal ridge on the west and a gently rising slope of outwash on the east. It was drained by a stream which ran parallel to the moraine and the deposit may represent a ponded area in the stream.

The morainal ridge, trending North-South, is part of the eastern edge of the Mountain morainal system. It is about 100 feet high and contains many large boulders, some 10 feet in diameter. The outwash is probably Cary, having formed when the ice stood at the Athelstane moraine to the east. The sand is medium- to coarse-grained and tan in color. The whole area had once been forest land but the part occupied by the marl has been cleared and is used as a trout farm. A very small stream drains the area and the water table is only a few inches below the surface.

The marl averages from 6 to 8 feet in thickness and is everywhere covered by 12 to 18 inches of black peaty material containing many wood fragments. The deposit rests on medium-grained sand which is red. The bottom 5 inches of marl is white and quite pure in composition. The marl is tan throughout the remainder of the section and plant matter increases toward the top. The entire section of marl is fossiliferous, but the 18 inches of black muck capping the marl contained no fossils.

Stratigraphic Section.

Coll.	Unit*		Inches
	6	Peat, black, abundant wood fragments, unfossiliferous..	18
1	5	Peat, dark brown to black, marly, fragments of wood throughout, fossiliferous...	8
2	4	Marl, brown, fine-grained, peaty, abundant wood fragments, fossiliferous	7
3-8	3	Marl, light tan, fine-grained, abundant plant matter, fossiliferous	49
9-10	2	Marl, grayish tan, mottled with areas of white, fine-grained, abundant plant matter, fossiliferous	16
11-12	1	Marl, white, small patches of gray, fine-grained, little plant matter, fossiliferous	14
		Total	112

* Units were sampled at approximately 8 inch intervals.

Waupaca Deposit

The marl of the Waupaca deposit (fig. 5) was laid down in a small lake or pond which formed in a depression in pitted outwash. The former lake is surrounded by knobby terrain composed of coarse-grained light-brown sand which contains numerous pebbles and some boulders. This topography seems characteristic of pitted outwash, the low places being the sites of former ice blocks. The deposit lies on the boundary between the Cary outwash and the Valders outwash (Thwaites, 1943, pl. 10) and it could not be determined where it was located in relation to this boundary. Most of the knobs have been excavated for sand and gravel and these depressions are filled with water.

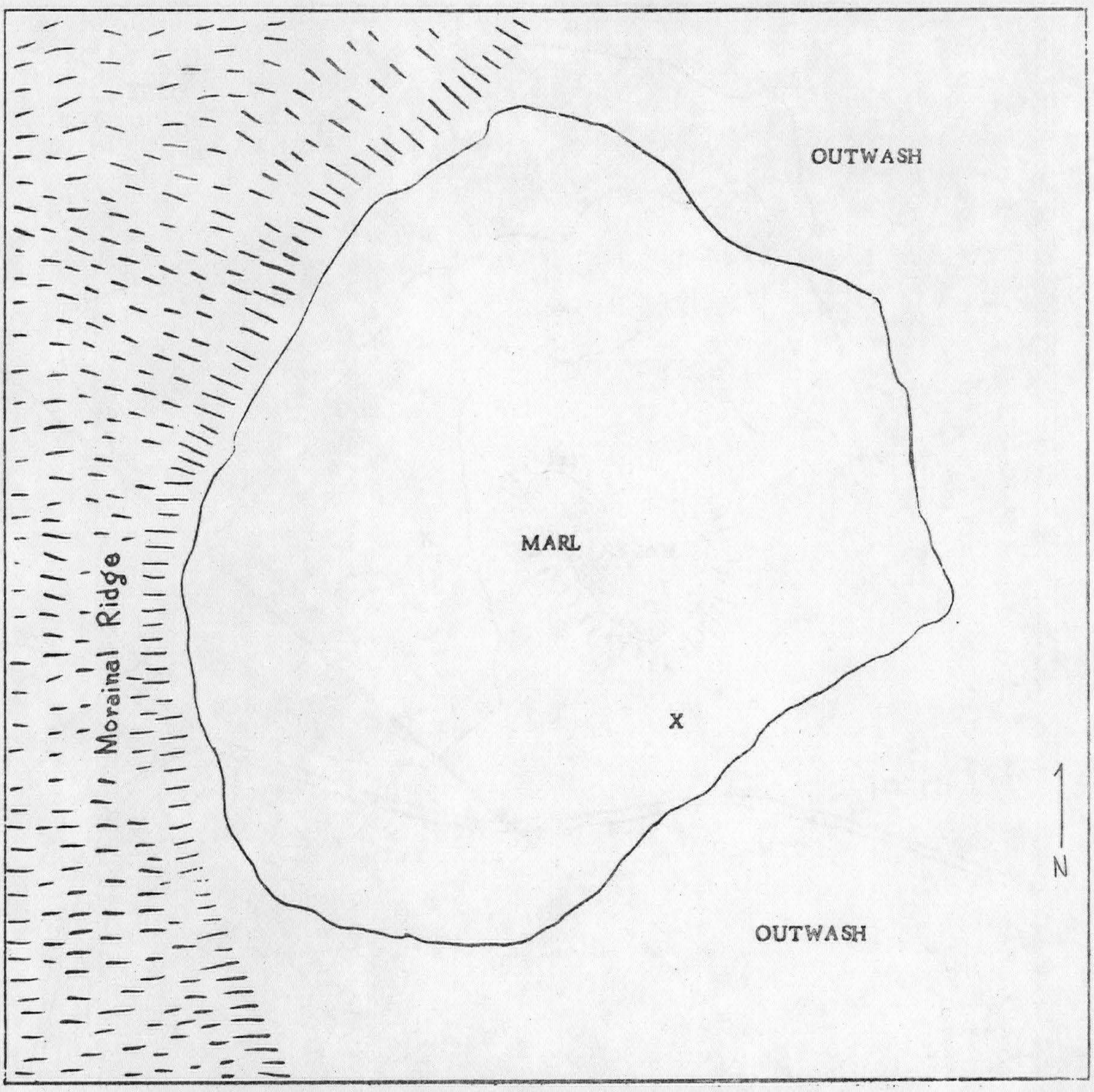


FIGURE 4. Sketch Map of the Mountain Deposit. X = Sampled Section.
Scale: 1 inch to 260 feet

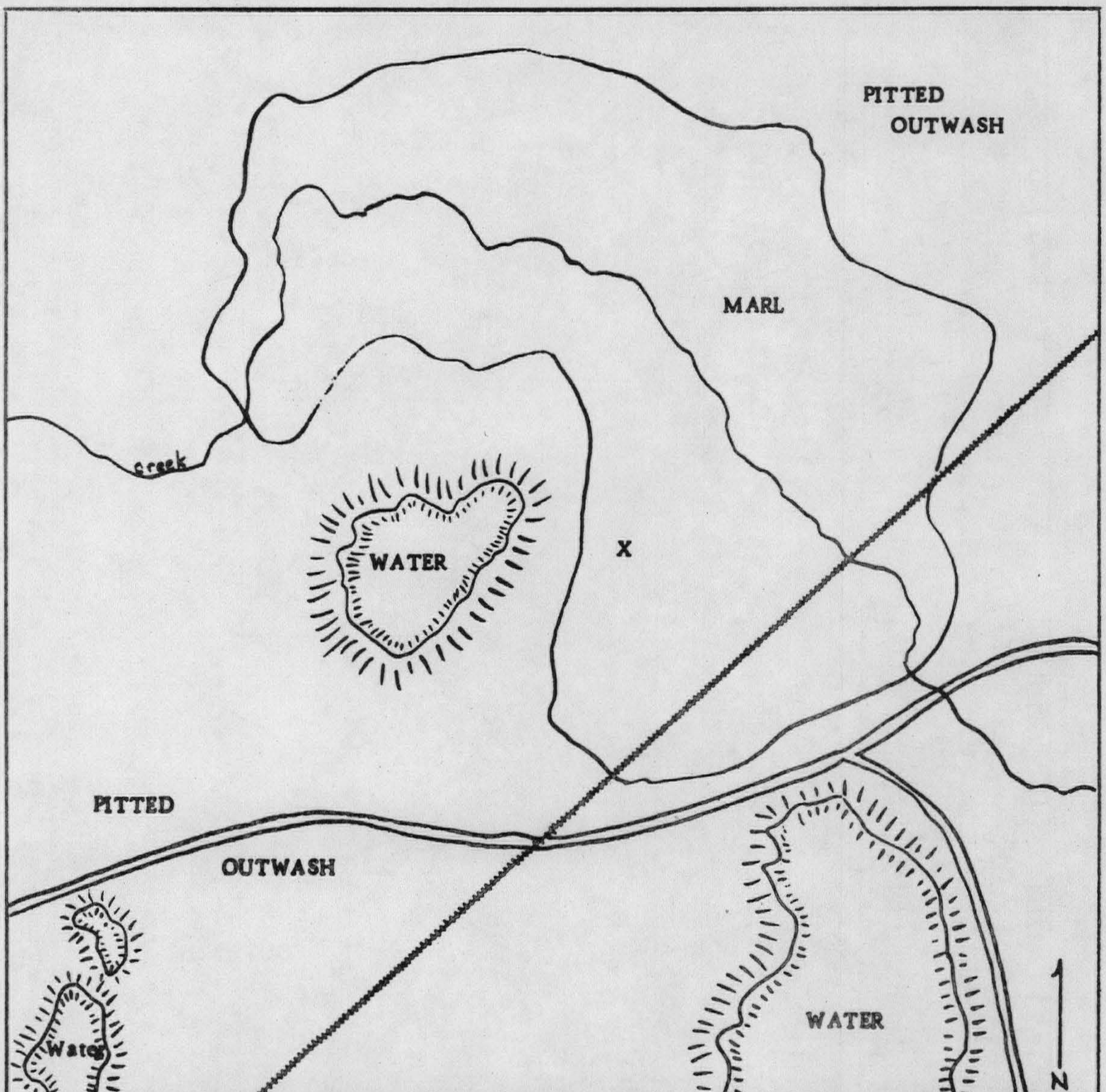


FIGURE 5. Sketch Map of the Waupaca Deposit. X = Sampled Section.
Scale: 1 inch to 265 feet

The lake and swamp sediments deposited in the low places between the knobs range in thickness from less than a foot to 21 feet. Steidtmann (1924, p. 148-149) states that the marl bed underlies 6 acres of open marsh. The logs of a few borings he made show the muck to be as thick as 19 feet over a foot of marl in some places and only two feet thick over 12 feet of marl in other places. In general it can be siad that the muck increases in thickness toward the northern edge of the deposit. Because of the swampy conditions, a section was taken near the edge so that it would not fill with water immediately and because the muck cover was thinnest here. The bottom 42-inch unit is composed of a fossiliferous light tan fine-grained marl. The next unit, 4 inches, is peat which contains shells, followed by another 4 inch unit of peat which has no shells, and this is covered by a 10 inch unit of black muck.

Stratigraphic Section

Coll.	Unit		Inches
1-5	5	Muck, black, crumbly, clayey, unfossiliferous	10
6-7	4	Peat, dark brown to black, well compacted, wood fragments, unfossiliferous	4
8-9	3	Peat, brown to dark brown, marly, few wood fragments, fossiliferous	4
10-11	2	Marl, brown, fine-grained, contains plant matter, fossiliferous	4
12-26*	1	Marl, white to light tan, dries gray, fine-grained, little plant matter, fossiliferous	39
		Total	61

* Collection No. 26 is 11 inches thick.

Harmony Deposit

The small pond which formed the Harmony deposit (fig. 6) developed in a shallow depression in gently rolling terrain of Valders ground moraine. The marl rests on a base of medium-grained sand which is unfossiliferous; it is capped everywhere by 8 to 24 inches of black muck. The gently rolling surrounding terrain and the thickness of lake sediments, 5 to 6 feet, seem to indicate a small shallow pond deposit. In contrast to the other deposits, the bottom 14 inches is composed of clayey, brown, calcareous fossiliferous silt rather than marl. The next 34 inches, however, is composed of fine-grained tan marl which is quite pure. The next unit is fossiliferous clay and the top unit is composed of 10 inches of black clayey unfossiliferous muck.

Stratigraphic Section

Coll.	Unit		Inches
1-4	4	Muck, black, clayey, crumbly, unfossiliferous..	8
5	3	Clay, dark brown to black, blocky, fossiliferous	2
6-22	2	Marl, tan, fine-grained, dries gray, blocky, stringers of peaty clay in upper 5 inches, sparse plant matter, fossiliferous	34
23-29	1	Silt, brown, coarse-grained, clayey, calcareous, very crumbly, few angular pebbles, fossiliferous	15
		Total	59

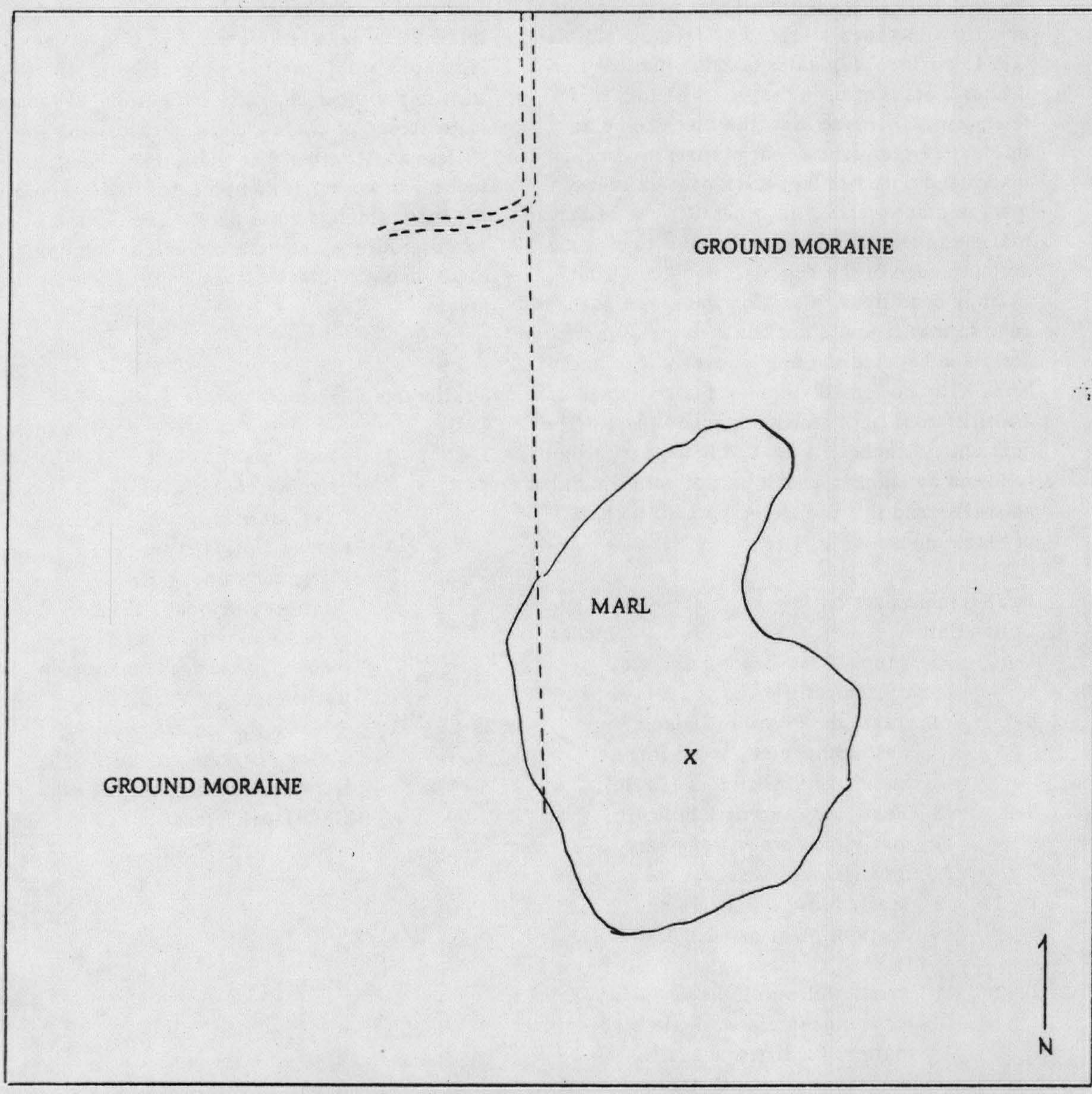


FIGURE 6. Sketch Map of the Harmony Deposit. X = Sampled Section.
Scale: 1 inch to 230 feet

SYSTEMATIC PALEONTOLOGY

GENERAL STATEMENT

This chapter is a summary of data for each species collected in the five northeastern Wisconsin deposits. A short synonymy is given which includes the original description of the species as well as the important references to that species for Wisconsin. The diagnosis of the shell includes only some of the important characteristics of the shell which can be seen in the fossil shell. This section also includes information on the ecology, general distribution, and geologic distribution of each species studied.

Much of the information contained in this section has been summarized from the data collected by previous workers in Pleistocene non-marine Mollusca in the Department of Geology, Ohio State University. Other important references used are Baker (1928), Pilsbry)(1946, 1948), Herrington (1962) and La Rocque (1963-1964).

Class Pelecypoda

Order Teleodesmacea

Family Sphaeriidae

SPHAERIUM LACUSTRE (Müller) 1774

Tellina lacustris Müller 1774, Verm. Terr. et Fluv., vol. 2, p. 204.

Musculium rosaceum Baker 1928, F. W. Moll. Wis., pt. 2, p. 358, pl. 99, figs. 19, 20.

Musculium jayense Baker 1928, F.W. Moll. Wis., pt. 2, p. 353, pl. 99, figs. 27, 28.

Musculium ryckholti Baker 1928, F.W. Moll. Wis., pt. 2, p. 359, pl. 99, figs. 6-9.

Sphaerium lacustre Herrington 1962, Rev. Sphaeriidae N. Am., p. 19, pl. 2, fig. 1.

TYPE LOCALITY. Europe, probably Denmark.

DIAGNOSIS. Shell small to medium, walls thin, anterior end not so high as posterior; beaks somewhat toward anterior end; striae moderately fine to fine; anterior end rounded, posterior end almost straight; hinge very long; lateral teeth slim but distinct, cardinal teeth weak. (Condensed from Herrington, 1962, pp. 19, 20).

ECOLOGY. This species is most plentiful in small lakes and ponds, but also occurs in large lakes, rivers, and creeks. It appears to prefer a muddy bottom. (Herrington, 1962, p. 20).

GENERAL DISTRIBUTION. Northwest Territories east to Nova Scotia; and south to Louisiana, Alabama, Georgia, and Florida.

GEOLOGIC DISTRIBUTION. Taylor and Hibbard (1955, p. 12) have recorded this species from the Illinoian of Oklahoma. This is also a common species among Late Pleistocene and Recent assemblages. The form ryckholti has been recorded from Early and Middle Pliocene deposits of Kansas and Oklahoma.

SPHAERIUM SULCATUM (Lamarck) 1818

Cyclas sulcata Lamarck 1818, Anim. sans Vert., 5, p. 560.

Sphaerium crassum Baker 1928, F.W. Moll. Wis., pt. 2, p. 319, pl. 94, figs. 11-13.

Sphaerium lineatum Baker 1928, F.W. Moll. Wis., pt. 2, p. 322, pl. 94, figs. 18-21.

Sphaerium simile Baker 1928, Ibid., p. 315, pl. 96, figs. 4-7.

Sphaerium simile planatum Baker 1928, Ibid., p. 317, pl. 317, pl. 96, figs. 8-10, pl. 98, figs. 29-33.

Sphaerium sulcatum Teskey 1954, Nautilus, vol. 68, p. 27.

TYPE LOCALITY. Lake George, N. Y.

DIAGNOSIS. Shell large, transversely oval, inflated, almost equipartite, rather solid; striae unevenly spaced; hinge long, lateral teeth short to medium in length, cardinals nearer anterior. (Herrington, 1962, p, 28, 29).

ECOLOGY. "Small lakes, also eddies in rivers and creeks. It has a preference for soft sand with vegetation; never found in swamps or ponds." (Herrington, 1962, p. 29).

GENERAL DISTRIBUTION. Alberta east to the Gaspé Peninsula; south to Wyoming, Iowa, South Dakota, Minnesota, Illinois, Indiana, Ohio, Pennsylvania, and Virginia. It probably does not extend south of the area covered by the glaciers. (Herrington, 1962, p. 29).

GEOLOGIC DISTRIBUTION. The general range of this species is from Early Pleistocene (Nebraskan) to Recent.

PISIDIUM NITIDUM Jenyns 1832

Pisidium nitidum Jenyns 1832, Trans. Cambr. Phil. Soc., vol. 4, p. 304, pl. 20, figs. 7-8.
Pisidium contortum Baker 1928, F.W. Moll. Wis., pt. 2, p. 415, pl. 100, figs. 26, 27.
P. glabellum Baker 1928, Ibid., p. 384, pl. 102, figs. 9-11.
P. minusculum Baker 1928, Ibid., p. 383, pl. 102, figs. 5-8.
P. pauperculum Baker 1928, Ibid., p. 421, pl. 100, figs. 22-25.
P. splendidulum Baker 1928, Ibid., p. 411, pl. 102, figs. 28-30.
P. tenuissimum Baker 1928, Ibid., p. 419, pl. 104, figs. 29-33.
P. nitidum Herrington 1962, Rev. Sphaeriidae N. Am., pp. 45, 46, pl. 5, fig. 6, pl. 7, fig. 17.

TYPE LOCALITY. Great Britain.

DIAGNOSIS. Shell moderately small, walls thin, rhomboid; beaks subcentral, broad; striae moderately fine; anterior end with a rounded slope joining ventral margin below in a rounded point; posterior end vertical or undercut; hinge long, laterals of moderate length, cardinals subcentral. (Condensed from Herrington, 1962, p. 45).

ECOLOGY. Herrington (1962, p. 46) gives its habitat as large ponds, bog ponds, lakes, creeks, and rivers, with a preference for shallow water.

GENERAL DISTRIBUTION. Eurasia and North Africa; North America, Northwest Territories east to Newfoundland and south throughout the United States except for the southeastern states.

GEOLOGIC DISTRIBUTION. It has been recorded by Taylor (1960, p. 48) for the Nebraskan. This species is common in deposits of Wisconsin age and living assemblages.

PISIDIUM CASERTANUM (Poli) 1791

Cardium casertanum Poli 1791, Test. utr. Sicil., vol. 1, p. 65, pl. 16, fig. 1.
Pisidium abditum Baker 1928, F.W. Moll. Wis., pt. 2, p. 407, pl. 103, figs. 1-5.
P. complanatum Baker 1928, Ibid., p. 402, pl. 103, figs. 9-11.
P. griseolum Baker 1928, F.W. Moll. Wis., Ibid., p. 412, pl. 104, figs. 25, 26.
P. neglectum Baker 1928, Ibid., p. 390, pl. 105, figs. 7, 8.
P. noveboracense Baker 1928, Ibid., p. 391, pl. 101, figs. 10-12, 20.
P. politum Baker, 1928, Ibid., p. 404, pl. 102, fig. 19.
P. politum decorum Baker 1928, Ibid., p. 405, pl. 102, figs. 20-22.
P. roperi Baker 1928, Ibid., p. 400, pl. 102, figs. 23-25.
P. subrotundum Baker 1928, Ibid., p. 409, pl. 101, figs. 21-23.

Pisidium subrotundum pumilum Baker 1928, F.W. Moll. Wis., pt. 2, p. 410, pl. 102, fig. 26.
P. superius Baker 1928, Ibid., p. 397.
P. casertanum Teskey 1954, Nautilus vol. 68, p. 27.
P. casertanum Herrington 1962, Rev. Sphaeriidae N. Am., pp. 33, 34, pl. 4, fig. 1, pl. 7, fig. 7.

TYPE LOCALITY. Sicily.

DIAGNOSIS. Shell rather long in outline, of moderate weight; beaks subcentral to a little farther back; striae rather fine; anterior end moderately long and rounded; posterior end truncate; hinge-plate moderately long, laterals distinct, cardinals near anterior cusps. (Condensed from Herrington, 1962, p. 33).

ECOLOGY. "P. casertanum has succeeded in adapting itself to a wide variety of habitats. One finds it in bog ponds, ponds, swamps that dry up for several months of the year, swamp-creeks, creeks with considerable current, rivers, and lakes, including the Great Lakes. This is by far the most common Pisidium." (Herrington, 1962, p. 34).

GENERAL DISTRIBUTION. Newfoundland and Labrador to British Columbia, as far north as the Arctic Circle. All of the United States except Hawaii, Kentucky, and North Dakota.

GEOLOGIC DISTRIBUTION. This species ranges from the Pliocene to the Recent and is common in deposits of Wisconsin age.

PISIDIUM VARIABILE Prime 1851

Pisidium variabile Prime 1851, Proc. Boston Soc. Nat. Hist., vol. 4, p. 163.
P. variabile Baker 1928, F.W. Moll. Wis., pt. 2, p. 381, pl. 101, figs. 1-4.
P. variabile Herrington 1962, Rev. Sphaeriidae N. Am., p. 50, pl. 3, fig. 4, pl. 1, fig. 4.

TYPE LOCALITY. Fresh Pond, near Cambridge, Massachusetts.

DIAGNOSIS. Shell heavy, varying from short and high to moderately long; beaks rather prominent, quite far back and broad; striae coarse to fine; anterior end begins near the proximal side of cusps and descends to where it joins ventral margin with an angle; posterior end broadly rounded, vertical or slightly undercut; hinge long, laterals rather short, cardinals central. (Condensed from Herrington, 1962, p. 50).

ECOLOGY. "Creeks, rivers, and lakes; usually in still water where soft sediments accumulate." (Herrington, 1962, p. 50).

GENERAL DISTRIBUTION. Eastern United States north of Virginia; Colorado and northward; Washington, Manitoba, Yukon.

GEOLOGIC DISTRIBUTION. This species is known only from the Wisconsin and Recent.

Class Gastropoda

Order Ctenobranchiata

Family Valvatidae

VALVATA LEWISI Currier 1868

Valvata lewisi Currier 1868, List Moll. of Mich., Kent Sci. Inst., Misc. Publ. No. 1, p. 9.
V. lewisi Baker 1928, F. W. Moll. Wis., pt. 1, p. 26, pl. 1, figs. 28-30.
V. lewisi Morrison 1932, Trans. Wis. Acad. Sci. Arts, and Letters, vol. 27, p. 366.

TYPE LOCALITY. Little Lakes, New York.

DIAGNOSIS. Shell turbinate, thin, shining; whorls 3 1/2, regularly convex, rapidly increasing in diameter, regularly striate, like the "winding of thread on a spool"; sutures deeply impressed;

spire depressed, apex flattened, spiral lines very fine, disappearing on second whorl; growth lines close together; aperture circular; lip simple; umbilicus rather wide, deep, exhibiting interior whorls. (Condensed from Baker, 1928, p. 27).

ECOLOGY. Baker (1928, p. 28) collected this snail in Prairie Lake in shallow water on a sand bottom in vegetation, and in Lake Butte des Morts in 1 meter of water on a mud bottom on plants. It appears to be largely a lake species.

GENERAL DISTRIBUTION. Mackenzie River south to the northern United States and east to the Atlantic.

GEOLOGIC DISTRIBUTION. This species occurs from the Kansan to the Recent.

REMARKS. This species was rare in the northeastern Wisconsin deposits.

VALVATA SINCERA Say 1824

Valvata sincera Say 1824, Rept. Long's Exped., vol. 2, p. 264, pl. 15, fig. 11.
V. sincera Baker 1928, F.W. Moll. Wis., pt. 1, p. 23, pl. 1, figs. 19-22.
V. sincera Solem 1952, Nautilus vol. 64, p. 129.

TYPE LOCALITY. "Northwest Territory" (Say).

DIAGNOSIS. Shell subglobose-conic, rather solid; whorls 4, evenly rounded, regularly increasing in diameter; sculpture of fine and regular striae; sutures well impressed; aperture circular; umbilicus round, deep, exhibiting the volutions almost to the apex. (Condensed from Baker, 1928, p. 23).

ECOLOGY. Generally regarded as a lake species, it has been found in deep water in Lake Michigan and Lake Superior. (Baker, 1928, p. 23).

GENERAL DISTRIBUTION. The species ranges from Newfoundland, Quebec, and Maine west to Western Ontario and Manitoba, south to southern Michigan and northern New York.

GEOLOGIC DISTRIBUTION. This species has been found in many late Pleistocene deposits and probably ranges from the Wisconsin to the Recent.

REMARKS. *V. sincera* is rare in all five deposits.

VALVATA TRICARINATA (Say) 1817

Cyclostoma tricarinata Say 1817, Jour. Acad. Nat. Sci. Phila., vol. 1, p. 13.
Valvata tricarinata Baker 1928, F. W. Moll. Wis., pt. 1, p. 11, pl. 1, figs. 1-3.
V. tricarinata Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 366.
V. tricarinata Solem 1952, Nautilus, vol. 65, p. 129.

TYPE LOCALITY. Delaware River.

DIAGNOSIS. Shell turbinate, thin, translucent, shining; whorls about 4, rapidly enlarging, flattened between the carinae, sloping upward from the carina to the suture on the upper surface; spire elevated but depressed at the apex; sculpture of coarse growth lines more or less equally spaced; sutures distinct, well impressed; body whorl large, with three distinct, sharp carinae, one on the shoulder, one on the periphery, and one on the base, which encircles the round, deep, funnel-shaped umbilicus; aperture circular, modified somewhat by the carinae. (Condensed from Baker, 1928, p. 11-12).

ECOLOGY. In Wisconsin, Baker (1928, p. 14) found *V. tricarinata* in shallow water to depths exceeding 9 meters. It has been found on mud, clay, sand, gravel and bare-rock bottoms, with or without vegetation in both streams and lakes.

GENERAL DISTRIBUTION. Great Slave Lake and the Mackenzie River south and east to New England and Virginia.

GEOLOGIC DISTRIBUTION. V. tricarinata was found in a Nebraskan deposit by Taylor (1960, p. 32). Many deposits of Wisconsin age contain this species.

REMARKS. Valvata tricarinata occurs in all five deposits, but is rare in the Harmony deposit. The forms (111) and (000) seem to be the most abundant. Many of the (111) forms have very well developed carinae.

Family Amnicolidae

AMNICOLA LIMOSA (Say) 1817

Paludina limosa Say 1817, Jour. Acad. Nat. Sci. Phila., vol. 1, p. 125.
Amnicola limosa Baker 1928, F.W. Moll. Wis., pt. 1, p. 93, pl. 6, figs. 1-6.
A. limosa Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 368.

TYPE LOCALITY. Delaware and Schuylkill rivers, Pa.

DIAGNOSIS. Broadly conic in shape, about 4.5 mm. high, 3 mm. wide, 4.5 whorls; apex blunt; later whorls round and somewhat shouldered, increasing gradually in size; body whorl round; aperture subrotund, mostly basal; umbilicus deeply perforate. (Condensed from Berry, 1943, p. 23).

ECOLOGY. This species has a wide range in distribution, occurring in creeks, rivers, and fresh- and brackish-water lakes. It generally is found in thick beds of Chara, Potamogeton, Vallisneria, and Elodea. The plants are not used for food, but they harbor rich colonies of diatoms on which the snail feeds. (Berry, 1943, p. 26).

GENERAL DISTRIBUTION. New England and New Jersey west to Utah, Manitoba south to Texas.

GEOLOGIC DISTRIBUTION. Amnicola limosa has been found in many deposits of Wisconsin age and should probably be regarded as ranging from Late Pleistocene to Recent.

AMNICOLA LUSTRICA Pilsbry 1890

Amnicola lustrica Pilsbry 1890, Nautilus, vol. 4, p. 53.
A. lustrica Baker 1928, F.W. Moll. Wis., pt. 1, p. 104, pl. 6, figs. 16-17, 26-27, text fig. 45.
A. lustrica Solem 1952, Nautilus, vol. 65, p. 129.

TYPE LOCALITY. Not specifically given: "New York to Illinois and Minnesota." (Pilsbry).

DIAGNOSIS. Shell small, about 4 mm., 5 whorls increasing gradually in size; apex elevated, acute, sutures deeply impressed, whorls shouldered and rounded; aperture ovate, umbilicus narrow, perforate. (Condensed from Berry, 1943, p. 30).

ECOLOGY. It occurs on stones in rivers and lakes and often on vegetation such as Vallisneria, Potamogeton, and Chara. It is often associated with A. limosa and generally inhabits the same type of environment. (Berry, 1943, p. 32).

GENERAL DISTRIBUTION. New York to Minnesota, and southern Ontario. Authentically reported from Indiana, Illinois, New York, Minnesota, Wisconsin, Michigan, Ohio, Pennsylvania, and southern Ontario.

GEOLOGIC DISTRIBUTION. It has been recorded from deposits of Wisconsin age and in general ranges from Late Pleistocene to Recent.

REMARKS. *Amnicola lustrica* was not present in the Harmony deposit.

Order Pulmonata

Family Lymnaeidae

LYMNAEA STAGNALIS (Linnaeus) 1758

Helix stagnalis Linnaeus 1758, Syst. Nat., ed. 10, p. 774.
Lymnaea stagnalis Baker 1911, Lymn. N. and M. Am., p. 136: synonymy.

TYPE LOCALITY. Europe.

DIAGNOSIS. Elongate or oval, ventricose at anterior end, thin; apex smooth; whorls 6 to 7, rapidly increasing, last whorl very large; spire long, pointed, acute; suture distinct; aperture large, broadly ovate.

ECOLOGY. This species is usually found in more or less stagnant parts of ponds or lakes and rivers around vegetation. It has been recorded by Baker (1928, p. 203) on mud bottoms in less than 1.5 meters of water.

GENERAL DISTRIBUTION. The species and its varieties may be described as circumboreal; in North America, south to about the 40th parallel of latitude.

GEOLOGIC DISTRIBUTION. This species has been recorded for Late Pleistocene deposits as well as living.

REMARKS. The species occurred only in the White Lake deposit, and as immature specimens which could not be identified to subspecies.

STAGNICOLA PALUSTRIS (Müller) 1774

Buccinum palustre Müller 1774, Verm. Terr. et Fluv., vol. 2, p. 131.
Stagnicola palustris Baker 1928, F. W. Moll. Wis., pt. 1, p. 212.
S. palustris Teskey 1954, Nautilus, vol. 68, p. 27.

TYPE LOCALITY. Europe.

DIAGNOSIS. Shell elongate to elongate-ovate, thin; covered with numerous crowded growth lines crossed by several elevated spiral lines; whorls 7, rounded, the last usually obese; spire sharp and pointed; aperture varying from roundly-ovate to long-ovate. (Condensed from Baker, 1928, pp. 212-213).

ECOLOGY. *Stagnicola palustris* occurs in both large and small bodies of water. Generally, it is found on floating sticks and submerged vegetation, on stones, and on muddy bottom. It inhabits both clear and stagnant water but prefers one that is not in motion. (Baker, 1928, p. 215).

GENERAL DISTRIBUTION. Circumboreal; northern Asia and Europe. North America from the Atlantic to the Pacific, all Canada south to New Mexico, the north-central and northeastern states.

GEOLOGIC DISTRIBUTION. This species has been recorded from the Kansan to the Recent.

REMARKS. *Stagnicola palustris* was found only in the Harmony deposit where it was rare.

FOSSARIA OBRUSSA (Say) 1825

Lymneus obrussus Say 1825, Jour. Acad. Nat. Sci. Phila., vol. 5, p. 123.
Fossaria obrussa Baker 1928, F.W. Moll. Wis., pt. 1, p. 293, pl. 16, fig. 14, pl. 18, figs. 14-24.
F. obrussa Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 371.
F. obrussa Solem 1952, Nautilus, vol. 65, p. 129.

TYPE LOCALITY. Harrowgate, Philadelphia County, Pennsylvania.

DIAGNOSIS. Shell subconic, pointed, oblong, thin, whorls 5 1/2, rounded, somewhat shouldered; the last whorl is large; spire acute, sharply conical; suture deeply indented; aperture very elongate-ovate. (Condensed from Baker, 1928, pp. 293, 294).

ECOLOGY. This species generally occurs in small bodies of water, as creeks, ponds, sloughs, bays, and marshy spots along river banks. It is commonly found on sticks, stones, and other debris that may be in the water or along its edge. (Baker, 1928, p. 296).

GENERAL DISTRIBUTION. From the Atlantic to the Pacific oceans, and from Mackenzie Territory, Canada, south to Arizona and northern Mexico.

GEOLOGIC DISTRIBUTION. F. obrussa has been recorded from the Pliocene of California (Baker, 1911, pp. 280, 281) and from numerous deposits of Pleistocene age. Hibbard and Taylor (1960, p. 94) give the range as early Pliocene to Recent.

REMARKS. A few specimens of F. obrussa obrussa were recorded for each deposit. The great majority of the specimens of the genus Fossaria were identified as the subspecies F. obrussa decampi.

FOSSARIA OBRUSSA DECAMPI (Streng) 1906

Limnaea desidiosa var. decampi Streng, 1906, Nautilus, vol. 9, p. 123.
Galba obrussa decampi Baker 1911, Lym. N. and M. Am., p. 289, pl. 32, figs. 15-22.
Fossaria obrussa decampi Baker 1928, F.W. Moll. Wis., pt. 1, p. 229, pl. 18, figs. 30-33; pl. 16, fig. 12.
F. obrussa decampi Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 371.

TYPE LOCALITY. Brook's Lake, Newaygo County, Michigan.

DIAGNOSIS. Shell small, oblong, somewhat inflated, subconic, rather solid; whorls 5, spire whorls convex, distinctly shouldered near the suture, body whorl much flattened in the middle; spire short, broadly conic, turreted, about as long as aperture; sutures deeply impressed; aperture long and narrow, somewhat elliptical, rounded below and forming a prominent shoulder above. (Condensed from Baker, 1928, p. 300).

ECOLOGY. Baker (1928, p. 300) states that the ecology of F. o. decampi is probably the same as that of F. obrussa which lives on the margins of small bodies of water, and on mud flats and debris.

GENERAL DISTRIBUTION. Maine west to Wisconsin; northern Michigan south to northern Illinois.

GEOLOGIC DISTRIBUTION. This species has been recorded from numerous deposits of Wisconsin age and from living assemblages in Manitoba, Minnesota, and Wisconsin.

REMARKS. Some of the specimens of F. obrussa decampi closely resemble F. galbana. An examination was made of a series of these specimens and it was found that of the two end members one was definitely F. o. decampi and the other resembled F. galbana with its more inflated body whorl. Between the two end members was a complete gradation of shells which it was difficult to place with one end member or the other. The great majority of specimens had a flattened body whorl and could be placed with F. o. decampi. Because the only apparent difference between the two was the shape of the body whorl it was decided to place them all in the subspecies F. obrussa decampi.

Family Planorbidae

GYRAULUS PARVUS (Say) 1817

Planorbis parvus Say 1817, Nicholson's Encycl., ed. 1, vol. 2, pl. 1, fig. 5.
Gyraulus parvus Baker 1928, F.W. Moll. Wis., pt. 1, p. 374, pl. 23, figs. 27-31, 39.
G. parvus Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 375.
G. parvus Baker 1945, Moll. Fam. Planorbidae, pp. 74, 270, 330, 336.
G. parvus Teskey 1954, Nautilus, vol. 68, p. 27.

TYPE LOCALITY. Delaware River, near Philadelphia, Pennsylvania.

DIAGNOSIS. Shell ultra-dextral, depressed, with a rounded periphery; growth lines oblique, crowded, fine; whorls about 3 1/2, rapidly enlarging, rounded below the periphery and somewhat flattened above on the body whorl and all the spire whorls; spire flat, first two whorls sunken below the body whorl; sutures deeply impressed; base slightly concave, umbilical region wide and shallow; aperture long-ovate, nearly in the same plane as the body whorl. (Condensed from Baker, 1928, p. 375).

ECOLOGY. Usually found in quiet bodies of water of small size, on mud, sandy mud, sand, gravel, or boulder bottoms; on logs and vegetation, in shallow water about a foot up to 4 feet. Its most suitable habitat seems to be in vegetation, in protected situations.

GENERAL DISTRIBUTION. Eastern North America east of the Rocky Mountains from Florida to Alaska and northern Canada.

GEOLOGIC DISTRIBUTION. This species is given a range of Middle Pliocene to Recent by Hibbard and Taylor (1960, p. 100). It is a common Pleistocene species which has been recorded for the Nebraskan, Aftonian, Sangamon, and Wisconsin.

REMARKS. Some of the shells of this species have an angulated body whorl similar to that of G. altissimus. A complete gradation, however, could be found between shells with a well angulated body whorl and shells with a well rounded body whorl. Few immature specimens had any angulation and the great majority of the mature specimens had the rounded body whorl. This was the only difference noted in the shells, and it probably represents only a genetic variation. On this basis, all the shells were identified as G. parvus.

ARMIGER CRISTA (Linnaeus) 1758

Nautilus crista Linnaeus 1758, Syst. Nat., ed. 10, p. 709.
Gyraulus (Armiger) crista Baker 1928, F.W. Moll. Wis., pt. 1, p. 385, text fig. 164.
Armiger imbricatus Baker 1945, Moll. Fam. Planorbidae, pp. 47, 50.

TYPE LOCALITY. Europe.

DIAGNOSIS. Shell very small, ultradextral, depressed, fragile; sculpture of rather coarse lines of growth crossed by very fine, crowded, spiral striae; whorls 2 1/2, rapidly increasing in diameter, flatly rounded below, costate on the periphery where the costae project conspicuously; costae reduced to low ridges on the upper and lower surfaces; spire flat; umbilicus open to apex; aperture ovate. (Condensed from Baker, 1928, p. 385).

ECOLOGY. This species lives in small lakes with shallow, quiet water, muddy or silty bottoms, and abundant vegetation.

GENERAL DISTRIBUTION. Europe; Asia; North America, from Maine west to Alberta, south to California, central Utah, Illinois, Indiana, and Ohio. As a Pleistocene fossil, as far south as Texas.

GEOLOGIC DISTRIBUTION. In North America it is known from Kansan, Sangamon, and Wisconsin deposits. Its general range is from Middle Pleistocene to Recent.

HELISOMA ANCEPS STRIATUM (F. C. Baker) 1902

Planorbis bicarinatus striatus Baker 1902, Nautilus, vol. 15, p. 120.

Planorbis antrosus striatus Walker 1918, Synopsis and Cat., p. 96.

Helisoma antrosa striata Baker 1928, F.W. Moll. Wis., pt. 1, p. 328, pl. 19, figs. 28-31.

Helisoma anceps striatum Baker 1945, Moll. Fam. Planorbidae, p. 400.

TYPE LOCALITY. Coldspring Park, Milwaukee, Wisconsin; Pleistocene.

DIAGNOSIS. Shell small, 3 1/2 whorls, dorsal and ventral carinae distinctly marked, cord-like, elevated; dorsal carina on center of upper side of body whorl; body whorl well rounded; umbilicus small, deep; surface sculpture of heavy spiral lines which become distinct ridges in many specimens; aperture higher than wide. (Condensed from Baker, 1928, p. 328).

ECOLOGY. Found in lake deposits, in marl, silts, and peaty marl; a number of deposits studied indicate that this variety lived in shallow, freshwater lakes, with abundant vegetation. The water in these lakes was probably colder than that of present-day lakes in the same area.

GENERAL DISTRIBUTION. Pleistocene deposits from Wisconsin and Illinois east to Quebec and south to Ohio and Indiana.

GEOLOGIC DISTRIBUTION. This variety is recorded for the Pleistocene but its exact range within it is not known. Several living occurrences have been recorded for northern Minnesota and Wisconsin.

REMARKS. All of the specimens of anceps had some indication of striations. Many of the shells had very well developed striations which became distinct ridges.

HELISOMA CAMPANULATUM (Say) 1821

Planorbis campanulatus Say 1821, Jour. Acad. Nat. Sci. Phila., vol. 2, p. 166.

Helisoma campanulatum Baker 1928, F. W. Moll. Wis., pt. 1, p. 345, pl. 21, figs. 1, 2, 4, 5, 8, 9, 13, 14.

Helisoma campanulatum Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 373.

H. campanulatum Solem 1952, Nautilus, vol. 65, p. 129.

TYPE LOCALITY. Cayuga Lake, New York.

DIAGNOSIS. Shell ultra-sinistral, discoidal, more or less rounded; whorls 4 1/2, rounded below and subcarinate above; spire flat; sutures deeply impressed; base of shell rounded, exhibiting 2 1/2 volutions with a deep umbilicus in the middle; aperture lunate. (Condensed from Baker, 1928, p. 346).

ECOLOGY. This species is characteristic of lakes, in shallow water, with rock, sand, or mud bottom, with or without vegetation. It is also found in quiet parts of rivers and small streams.

GENERAL DISTRIBUTION. Vermont west to North Dakota, south to Ohio and Illinois, north to the Mackenzie drainage.

GEOLOGIC DISTRIBUTION. The range of this species is from Late Wisconsin to Recent.

PLANORBULA ARMIGERA (Say) 1818

Planorbis armigerus Say 1818, Jour. Acad. Nat. Sci., Phila., vol. 2, p. 164.

Planorbula armigera Baker 1928, F.W.

Moll. Wis., pt. 1, p. 355, pl. 8, figs. 27-30.
Planorbula armigera Baker 1945, Moll. Fam. Planorbidae, pp. 176, 318, 326, 336.
P. armigera Solem 1952, Nautilus, vol. 65, p. 129.
P. armigera Teskey 1954, Nautilus, vol. 68, p. 27.

TYPE LOCALITY. Upper Missouri.

DIAGNOSIS. Shell ultra-dextral, depressed; sculpture of fine, oblique growth lines; whorls 4 1/2, slowly increasing in diameter; spire concave; umbilical region round, deep, rather wide, funnel-shaped; aperture subovate, narrowed by 6 teeth. (Condensed from Baker, 1928, p. 355).

ECOLOGY. This is a species of small stagnant bodies of water, even found in marshy areas in disconnected pools of water. It seems to prefer mud bottoms but can live on a bottom of meadow grass or on logs. It is seldom found in water more than three feet deep.

GENERAL DISTRIBUTION. New England to Great Slave Lake; Manitoba, Saskatchewan, and Ontario, south to Georgia and Louisiana.

GEOLOGIC DISTRIBUTION. Its general range is Nebraskan to Recent. It has been found in numerous deposits of Wisconsin age.

PROMENETUS EXACUOUS (Say) 1821

Planorbis exacuous Say 1821, Jour. Acad. Nat. Sci. Phila., vol. 2, p. 168.
Menetus exacuous Baker 1928, F.W. Moll. Wis., pt. 1, p. 361, pl. 23, figs. 1-5.
M. exacuous Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 374.
Promenetus exacuous exacuous Baker 1945, Moll. Fam. Planorbidae, pp. 24, 181, 318, 328, 336.

TYPE LOCALITY. Lake Champlain, New York, Vermont, and Quebec.

DIAGNOSIS. Shell ultra-dextral, very much depressed, with an acute periphery; whorls 4, rapidly increasing in diameter; spire very flat; sutures well impressed; umbilicus rather narrow, deep; aperture ovate. (Condensed from Baker, 1928, p. 361).

ECOLOGY. In quiet, more or less marshy places, in shallow water, with soft mud bottom; in streams always on mud flats in quiet water.

GENERAL DISTRIBUTION. Northern United States east of the Rockies; Canada south to New Mexico.

GEOLOGIC DISTRIBUTION. Hibbard and Taylor (1960, p. 107) give Sangamon to Recent. It is commonly found in deposits of Wisconsin age.

Family Ancylidae

FERRISSIA PARALLELA (Haldeman) 1841

Ancylus parallelus Haldeman 1841, Monogr., pt. 2, p. 3.
Ferrissia parallela Baker, 1928, F.W. Moll. Wis., pt. 1, p. 395, pl. 29, figs. 1-5.
F. parallela Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 375.

TYPE LOCALITY. New England.

DIAGNOSIS. Shell narrow, elongate, lateral margins nearly straight, widening more or less anteriorly, ends well rounded; anterior slope rather long, slightly convex; posterior slope shorter than anterior, straight or slightly concave; apex sub-acute, slightly anterior of the shell. (Condensed from Baker, 1928, p. 396).

ECOLOGY. In quiet water, one to six feet deep, it is found on plants, usually in ponds or lakes.

GENERAL DISTRIBUTION. Nova Scotia and New England west to Minnesota, Manitoba south

fine, oblique growth lines; whorls 4 1/2, slowly increasing in diameter; spire concave; umbilical region round, deep, rather wide, aperture subovate, narrowed by
States east of the Rockies; Canada south to New Mexico.
GEOLOGIC DISTRIBUTION. Hibbard and Tay-

to Rhode Island, central New York, northern Ohio, and Indiana.

GEOLOGIC DISTRIBUTION. The general range for this species is Pliocene (Taylor, 1960, p. 61) to Recent. It is commonly found in deposits of Wisconsin age.

Family Physidae

PHYSA GYRINA Say 1821

Physa gyrina Say 1821, Jour. Acad. Nat. Sci. Phila., vol. 2, p. 171.
Physella gyrina Baker 1928, F.W. Moll. Wis., pt. 1, p. 449, pl. 27, figs. 30-35, 37-40; pl. 28, figs. 1, 5, 6.
Physa gyrina Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 376.

TYPE LOCALITY. Bowyer Creek, near Council Bluffs, Iowa.

DIAGNOSIS. Shell large, elongate or subcylindrical, rather thick; sculpture of coarse growth lines; whorls 5-6, the last rather large, compressed or slightly inflated, spire rather long, acute, whorls well rounded; aperture 5/10 to 7/10 the length of the entire shell. (Condensed from Baker, 1928, p. 450).

ECOLOGY. It is characteristic of shallow, slow-moving and stagnant bodies of water.

GENERAL DISTRIBUTION. United States east of the Mississippi except that it ranges into Texas; Eastern Canada (Ontario, Quebec), northward to the Arctic regions.

GEOLOGIC DISTRIBUTION. This species has been recorded as far back as the Nebraskan by Taylor (1960, pp. 32, 39). It is a common species of late Pleistocene and Recent assemblages.

APLEXA HYPNORUM (Linnaeus) 1758

Bulla hypnorum Linnaeus 1758, Syst. Nat., ed. 10, p. 727.
Aplexa hypnorum Baker 1928, F.W. Moll. Wis., pt. 1, p. 473, pl. 19, figs. 1-4.
A. hypnorum Morrison 1932, Trans. Wis. Acad. Sci., Arts, and Letters, vol. 27, p. 377.
A. hypnorum Teskey 1954, Nautilus, vol. 68, p. 27,

TYPE LOCALITY. Europe.

DIAGNOSIS. Shell of medium size, elongate, thin; whorls more than six, the last long, narrow, compressed; spire long and pointed, whorls rounded; aperture of medium size, about half the length of the shell. (Condensed from Baker, 1928, p. 473).

ECOLOGY. It inhabits temporary pools, swamps, and intermittent streams; prefers woodland pools that are dry in summer, but will also live in small clean creeks on mud bottom.

GENERAL DISTRIBUTION. Northern Europe, Asia, and America. Northern United States from the Cascades to the Atlantic, southward to the vicinity of the Ohio River, Colorado, Utah, and Kansas. As a Pleistocene fossil it ranges farther south.

GEOLOGIC DISTRIBUTION. Hibbard and Taylor (1960, p. 121) give this species a range of Early Pleistocene (Nebraskan) to Recent.

TERRESTRIAL GASTROPODS

Order Pulmonata

Family Zonitidae

EUCONULUS FULVUS (Müller) 1774

EUCONULUS FULVUS (Müller) 1774

Helix fulva Müller 1774, (part), Hist. Vermium, vol. 2, p. 56.
Euconulus fulvus Pilsbry 1946, Land Moll. N. Am., vol. 2, pt. 1, p. 235
E. fulvus Levi and Levi 1950, Nautilus, vol. 63, p. 134.
E. fulvus Teskey 1954, Nautilus, vol. 68, p. 26.

TYPE LOCALITY. Fridrichsdal, Denmark.

DIAGNOSIS. Shell thin, minutely perforate or closed; spire conic with slightly convex outlines and obtuse apex; periphery rounded or weakly angular, base convex; aperture lunate. (Condensed from Pilsbry, 1946, p. 236).

ECOLOGY. This species lives among damp leaves in well-shaded places, especially under hardwood trees. It is common in drift debris of creeks and rivers.

GENERAL DISTRIBUTION. "Almost throughout the Holarctic realm, but wanting in the Gulf and South Atlantic States from Texas to North Carolina." (Pilsbry, 1946, p. 236).

GEOLOGIC DISTRIBUTION. In North America this species is known for the Middle Pliocene to Recent and is quite common in deposits of Wisconsin age.

NESOVITREA BINNEYANA (Morse) 1864

Hyalina binneyana Morse 1864, Jour. Portland Soc. Nat. Hist., vol. 1, pp. 13, 61, figs. 25, 26; pl. 2, fig. 9; pl. 6, fig. 27.
Retinella binneyana Pilsbry 1946, Land Moll. N. Am., vol. 2, pt. 1, p. 259, fig. 127a.
R. binneyana Levi and Levi 1950, Nautilus, vol. 63, p. 134.
Nesovitrea binneyana Forcart 1957, Arch. f. Moll., vol. 86, p. 110.

TYPE LOCALITY. Southern Maine.

DIAGNOSIS. "Shell thin, pellucid, nearly colorless, composed of nearly four whorls gradually enlarging; spire slightly elevated; aperture well rounded, umbilicus showing all the volutions." (Morse, 1864).

ECOLOGY. This species inhabits damp woodlands, especially those of deciduous trees; occasionally found in *Sphagnum* bogs.

GENERAL DISTRIBUTION. Quebec west to Western Ontario; south to Wisconsin, Ohio, Pennsylvania, New York, and Maine.

GEOLOGIC DISTRIBUTION. This species has been recorded only for Late Wisconsin and Recent assemblages.

Family Endodontidae

HELICODISCUS PARALLELUS (Say) 1821

Planorbis arallellus Say 1821, Jour. Acad. Nat. Sci. Phila., vol. 2, p. 164; corrected to *parallelus* in the Index, p. 407.
Helicodiscus parallelus Pilsbry 1948, Land Moll. N. Am., vol. 2, pt. 2, p. 625, fig. 339.
H. parallelus Levi and Levi 1950, Nautilus, vol. 63, p. 135.
H. parallelus Solem 1952, Nautilus, vol. 65, p. 129.
H. parallelus Teskey 1954, Nautilus, vol. 68, p. 26.

TYPE LOCALITY. Council Bluff, Iowa.

DIAGNOSIS. Shell small, disk-shaped, the upper surface flat or very slightly convex; broadly umbilicate; whorls 4 to 4 1/2, convex, very narrow, and slowly increasing, the last whorl rounded at periphery and base; aperture narrow, lunate. (Condensed from Pilsbry, 1948, p. 625).

ECOLOGY. On decaying wood and damp leaves, in shady, humid places.

GENERAL DISTRIBUTION. Manitoba east to Newfoundland, Prince Edward Island, New Brunswick, and Maine, south to Oklahoma, Arkansas, Alabama, and Georgia.

GEOLOGIC DISTRIBUTION. H. parallelus has been recorded for the Nebraskan to Recent. It occurs in numerous deposits of Wisconsin age.

Family Succineidae

SUCCINEA AVARA Say 1824

Succinea avara Say 1824, Appendix to Long's Second Exped., vol. 2, p. 260, pl. 15, fig. 6.
Succinea avara Pilsbry 1948, Land Moll. N. Am., vol. 2, pt. 2, p. 837, fig. 455, a-k.
S. avara Levi and Levi 1950, Nautilus, vol. 63, p. 136.
S. avara Solem 1952, Nautilus, vol. 65, p. 129.
S. avara Teskey 1954, Nautilus, vol. 68, p. 26.

TYPE LOCALITY. Northwest Territory.

DIAGNOSIS. Shell slender, fragile; little more than 3 whorls, very strongly convex; sutures deep; aperture ovate, two-thirds the length of the shell or less. (Modified from Pilsbry, 1948, p. 837).

ECOLOGY. Usually found on vegetable debris thrown up on muddy shores, or on the muddy banks of ditches, often exposed to the sun; also in swampy places in meadows. (Pilsbry, 1948, p. 839).

GENERAL DISTRIBUTION. Mackenzie District south to British Columbia, California, and Mexico; east to Quebec, New Brunswick, and Newfoundland, south to Florida.

GEOLOGIC DISTRIBUTION. This species ranges from Yarmouth to Recent with numerous occurrences recorded for the Wisconsin.

Family Strobilopsidae

STROBILOPS LABYRINTHICA (Say) 1817

Helix labyrinthica Say 1817, Jour. Acad. Nat. Sci. Phila., vol. 1, p. 124.
Strobilops labyrinthica Pilsbry 1948, Land Moll. N. Am., vol. 2, pt. 2, p. 854, fig. 463.
S. labyrinthica Levi and Levi 1950, Nautilus, vol. 63, p. 136.
S. labyrinthica Teskey 1954, Nautilus, vol. 68, p. 26.

TYPE LOCALITY. Philadelphia, Pennsylvania.

DIAGNOSIS. Shell narrowly umbilicate, dome-shaped, the periphery obtusely subangular; whorls 5 1/2, convex, very slowly widening; sculptured with narrow, obliquely radial ribs; aperture semilunar. (Condensed from Pilsbry, 1948, p. 854).

ECOLOGY. Under loose bark of logs, in half-decayed wood, among dead leaves and in sod at the bases of trees. (Pilsbry, 1948, p. 854).

GENERAL DISTRIBUTION. Manitoba, east to New Brunswick and Maine; south to Georgia and Alabama.

GEOLOGIC DISTRIBUTION. Hibbard and

Taylor (1960, p. 121) give the range of the species as Late Pliocene to Recent.

Family Pupillidae

VERTIGO TRIDENTATA Wolf 1870

Vertigo tridentata Wolf 1870, Am. Jour. Conch., vol. 5, p. 198, pl. 17, fig. 1.
Vertigo tridentata Pilsbry 1948, Land Moll. N. Am., vol. 2, pt. 2, p. 965, fig. 518: 1-3.

TYPE LOCALITY. Canton, Illinois.

DIAGNOSIS. Shell ovate to tapering oblong; surface smooth; last whorl somewhat flattened externally over the lower palatal fold, with a rather narrow but generally distinct crest behind the lip; outer lip projects forward and slightly inward near the middle, parietal lamella high, rather short, columellar lamella blunt, directed downward, lower-palatal fold strong developed, upper-palatal fold quite small or occasionally wanting. (Condensed from Pilsbry, 1948, p. 965).

ECOLOGY. Usually found in shady places around green weeds, sometimes climbing on the weeds.

GENERAL DISTRIBUTION. Maine and Quebec west to Ontario and Minnesota; south to New Jersey, Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Missouri, and Texas.

GEOLOGIC DISTRIBUTION. V. tridentata has been recorded from the Yarmouth to the Recent.

GASTROCOPTA PENTODON (Say) 1821

Vertigo pentodon Say 1821, Jour. Acad. Nat. Sci. Phila., vol. 2, p. 376.
Gastrocopta pentodon Pilsbry 1948, Land Moll. N. Am., vol. 2, pt. 2, p. 886, fig. 477: 2, 3, 5-8.
Gastrocopta pentodon Teskey 1954, Nautilus, vol. 68, p. 26.

TYPE LOCALITY. Pennsylvania.

DIAGNOSIS. Shell rimate, oblong-conic with obtuse summit; whorls 5, convex, the last with a rounded ridge or crest close behind the lip, flattened near the base behind the ridge; usually five teeth. (Modified from Pilsbry, 1948, pp. 886, 888).

ECOLOGY. Lives on wooded hillsides or in well-drained groves, among leaves in the underbrush; also common among moss and grass in forest and on open slopes.

GENERAL DISTRIBUTION. Prince Edward Island, Maine, Quebec, Ontario, Manitoba, and British Columbia, south to Mexico and Guatemala, but not on the Pacific slope.

GEOLOGIC DISTRIBUTION. Baker (1920, p. 388) recorded this species for the Yarmouth and Sangamon. It has more recently been recorded for Late Wisconsin deposits. The species in general ranges from the Yarmouth to the Recent.

COMPOSITION OF FAUNA

General Statement

The non-marine molluscan fauna of the five extinct lakes of northeastern Wisconsin is represented by a total of 30 species. Of these 5 are sphaeriid clams, 18 are fresh water gastropods, 5 lung-breathers and 13 gill-breathers, and 7 are terrestrial gastropods. (See Table 1). All of these species were studied quantitatively as well as qualitatively in an attempt to determine

TABLE 1. SPECIES PRESENT IN THE FIVE NORTHEASTERN WISCONSIN DEPOSITS.

Species	White Lake	Spur Lake	Mountain	Waupaca	Harmony
Sphaerium lacustre	X	X	X	X	O
S. sulcatum	X	X	X	X	O
Pisidium casertanum	O	X	X	X	X
P. nitidum	X	O	O	O	O
P. variabile	X	X	X	X	O
Valvata lewisi	X	O	O	O	O
V. sincera	X	X	X	X	X
V. tricarinata	X	X	X	X	X
Amnicola limosa	X	X	X	X	X
A. lustrica	X	X	X	X	O
Lymnaea stagnalis	X	O	O	O	O
Stagnicola palustris	O	O	O	O	X
Fossaria obrussa	X	X	X	O	X
F. obrussa decampi	X	X	X	X	X
Gyraulus parvus	X	X	X	X	X
Armiger crista	X	O	O	X	X
Helisoma anceps striatum	X	X	X	X	X
H. campanulatum	X	X	X	X	X
Promenetus exacuous	O	X	X	X	O
Planorbula armigera	O	X	X	X	O
Ferrissia parallela	X	X	O	X	X
Physa gyrina	X	X	X	X	X
Aplexa hypnorum	O	O	O	O	X
Euconulus fulvus	O	O	X	O	O
Nesovitrea binneyana	O	X	O	O	O
Succinea avara	X	X	O	X	X
Helicodiscus parallelus	O	O	O	O	X
Strobilops labyrinthica	O	X	O	X	O
Gastrocopta pentodon	O	O	O	X	O
Vertigo tridentata	O	X	O	X	X
Total species:	19	21	17	21	17

X = Species present; O = Species absent.

TABLE 2. NUMBER OF SHELLS PER 1000 MILLILITERS OF SEDIMENT.

Collection	White Lake	Spur Lake	Mountain	Waupaca	Harmony
1	0	3730	1150	0	0
2	0	2800	4000	0	0
3	0	3066	5780	0	0
4	0	2026	6000	0	0
5	5332	973	4525	0	277
6	3180	810	5816	0	2333
7	5200	500	5428	0	3000
8	5240	485	4000	1300	1750
9	5664	554	4400	4400	1846
10	4800	611	4285	5200	1416
11	4616	675	1765	4000	1270
12	4340	405	1640	4142	1450
13	4308	370		5088	1500
14	5816	500		3412	1385
15	5424	383		4500	1051
16	6000	215		1670	750
17	5452	260		1360	690
18	4740	403		5140	1210
19	4572			3000	700
20	4000			2180	810
21	6000			2100	1070
22	6180			4000	850
23	5664			2160	680
24	750			2130	725
25	340			2900	710
26	6000			1665	550
27	565				600
28	4445				770
29	6000				720
30	7640				
31	5816				
32	74				
33	0				
34	0				
35	0				
36	0				

how the abundance of species would vary with lithology and how it might reflect a fluctuation in environmental conditions. In this study it is assumed that the species occurring most abundantly are indigenous or native to the environment, and that the species occurring in lesser numbers are probably intruders to the environment. The study has taken into account the fact that some genera, such as Ferrissia, Promenetus, and Armiger, occur in small percentages even in favorable environments.

The quantity of shells per 2 inch collection was determined and this is expressed as the number of shells per 1000 milliliters of sediment. (See Table No. 2, opposite page). All of the collections are numbered from the top of the deposit starting with number 1; in order to locate a given collection in the proper unit the reader is referred back to the stratigraphic section in the chapter on Pleistocene Geology (pp. 11-20). The distribution of species within each deposit is shown in two ways: in tables, compiled for every deposit, showing the percent of each species in each collection, and in pie-shaped diagrams showing diagrammatically the percent of each species in each collection.

White Lake Deposit

The molluscan fauna of the White Lake deposit is composed of nineteen species. (See Table 3, p. 39). Four species of sphaeriid clams, five species of gill-breathing fresh water gastropods, 9 species of lung-breathing fresh water gastropods, and one species of terrestrial gastropod are represented. Five of the species occur in sufficient quantities to be considered indigenous throughout the section. Five other species are common in various parts of the section. (See Table 3 and Plates II to VI).

The number of shells per 1000 milliliters of sediment shows a few notable variations throughout the section and these seem to be controlled by lithology. (See Table 2, opposite page). The lowest unit in the deposit is an unfossiliferous peat. The next, unit 7, is also a peat but contains a few shells. Collection 31 in unit 3 is the first abundantly fossiliferous unit and this abundance continues through the marl of units 3, 4, and 5. A sharp reduction in the number of shells takes place in unit 6, collection 27, which is a peat. In the next unit, a marl, the shells are again abundant but decline in number in the next two units, 8 and 9, which are peat and sand respectively. Units 10, 11, and 12 are marl, and the shells are abundant and show relatively little fluctuation. There is a small decrease in the number of shells in collection 6, a peat, but not so sharp a decrease as in the other peat units. The uppermost fossiliferous unit is marl which contains a normal abundance of shells. The top unit is an unfossiliferous black muck.

The five most abundant species in the deposit are Pisidium nitidum, Valvata tricarinata, Amnicola limosa, A. lustrica, and Gyraulus parvus. The clam Pisidium nitidum is rare in the first nine units but becomes much more abundant from unit 10 through 14, averaging 20 to 25 percent of the population. The species Pisidium variabile, however, is fairly common in the first 9 units but becomes rare throughout the remainder of the section.

Valvata tricarinata occurs as less than 12 percent of the population from collections 32 through 17, except for collection 28 where it is 24 percent. From collection 16 upward it gradually increases to where it is the most abundant species in the uppermost collections. The two species of Amnicola, A. limosa and A. lustrica, follow two very different courses through the deposit. In the 15 lowest collections A. limosa is uncommon (less than 10 percent) whereas A. lustrica makes up between 25 and 90 percent of the population in the same interval. From collection 17 upward, however, A. limosa increases in abundance and A. lustrica decreases so that A. limosa is more abundant in the upper part of the deposit.

A general increase in percentage upward in the section is shown by Gyraulus parvus, Fossaria obrussa decampi, and Helisoma anceps striatum. The uncommon species show no definite trends. Of the species that occur abundantly or commonly in the deposit, all increase upward in the section except Pisidium variabile and Amnicola lustrica. The environment near the top of the deposit seems favorable to more species than that near the base. Although the percentages of the various species fluctuate somewhat in the marl units, they are more noticeably affected in the units of peat and peaty marl.

Spur Lake Deposit

Twenty-one species of non-marine mollusks are represented in the Spur Lake deposit. Of these, 4 are sphaeriid clams, 4 are gill-breathing fresh water gastropods, 9 are lung-breathing fresh water gastropods, and 4 are terrestrial gastropods. Although this large number of species occurs in the deposit, only 2 species are abundant enough to be considered indigenous throughout. Five other species occur in sufficient number to be considered common in certain parts of the section. The other 14 species are relatively rare in the deposit. (See Table 4 and Plates VII to IX).

The composition of the marl in this deposit is very homogeneous throughout the section and is all included in one unit. Only the top 3 feet of the section was studied. The number of shells in the section remains fairly constant from collection 18 through collection 5. There is a slight and gradual increase in the number of shells throughout this interval but the number of shells per 1000 milliliters of sediment ranges only from about 220 to 970 with the average between 400 and 600. (See Table 2).

A very sharp increase in the number of shells takes place in collections 4 through 1. This apparently marks a time when the environment of the lake became favorable for abundant reproduction of mollusks.

The two most abundant species are Pisidium casertanum and Gyraulus parvus. The combination of these two species makes up from 80 to 95 percent of the total population in the lower half of the collected section. From collection 9 through 1 the other species become more common and make up a greater part of the population. G. parvus is the most abundant species throughout the deposit. This is probably due to the fact that the marl contains abundant vegetation, which is favorable to this species. P. casertanum is more numerous in the lower half of the deposit than in the upper half. It is the lowest in percentage between collections 9 and 5. That interval also marks the most abundant period for Helisoma anceps striatum. Pisidium variabile is common throughout averaging about 3 percent except in collections 6 to 3 where it increases to 9 to 13 percent. Valvata tricarinata is rare in collections 18 through 12, but increases to 14

EXPLANATION OF ABBREVIATIONS FOR TABLES 3 TO 7.

AC	Armiger crista	HC	Helisoma campanulatum	PV	Pisidium variabile
AH	Aplexa hypnorum	HP	Helicodiscus parallelus	SA	Succinea avara
AI	Amnicola limosa	HS	Helisoma anceps striatum	SL	Sphaerium lacustre
AU	Amnicola lustrica	LS	Lymnaea stagnalis	SL	Strobilops labyrinthica
EF	Euconulus fulvus	NB	Nesovitrea binneyana	SP	Stagnicola palustris
FD	Fossaria obrussa decampi	PA	Planorbula armigera	SS	Sphaerium sulcatum
FO	Fossaria obrussa	PC	Pisidium casertanum	VL	Valvata lewisi
FP	Ferrissia parallela	PE	Promenetus exacuous	VR	Vertigo tridentata
GN	Gastrocopta pentodon	PG	Physa gyrina	VS	Valvata sincera
GP	Gyraulus parvus	PN	Pisidium nitidum	VT	Valvata tricarinata

TABLE 3. VERTICAL DISTRIBUTION OF SPECIES IN THE WHITE LAKE DEPOSIT.[1]

Coll.	SL	SS	PN	PV	VL	VS	VT	AI	AU	LS	FO	FD	GP	AC	HS	HC	FP	PG	SA
5	-	0.1	16.1	-	-	0.3	23.9	17.5	20.1	-	-	4.8	9.5	-	5.1	0.4	-	1.8	-
6	-	0.2	21.1	-	0.6	0.2	24.8	12.0	8.2	-	-	9.8	18.7	-	3.7	0.1	-	2.9	-
7	-	-	31.1	0.4	-	0.3	23.2	16.9	7.5	-	-	3.6	11.9	-	-	2.7	-	1.5	-
8	0.1	0.3	15.8	-	-	0.2	22.5	15.8	5.5	-	-	7.2	19.1	-	2.3	6.7	-	11.8	-
9	0.1	-	26.6	-	-	0.2	24.4	10.6	10.8	-	-	6.3	12.3	-	5.0	0.4	-	3.1	-
10	0.4	0.2	13.2	-	-	-	14.0	16.1	2.0	-	-	9.2	20.0	-	7.3	1.4	-	16.9	-
11	0.2	-	29.1	0.2	-	-	18.9	15.1	8.6	-	-	2.4	14.4	-	4.7	0.4	-	7.4	-
12	-	0.1	19.0	0.2	-	-	20.3	21.3	5.5	-	-	1.9	20.0	-	0.9	3.6	-	6.7	-
13	-	0.1	25.4	-	-	-	14.3	29.8	10.2	0.1	-	1.8	11.2	-	0.8	-	-	5.7	-
14	-	-	25.6	1.1	-	-	19.7	22.9	14.3	-	-	3.2	8.9	0.1	0.4	0.8	-	2.6	-
15	-	-	18.9	0.5	-	-	23.7	26.0	15.4	-	-	2.7	8.5	-	2.2	0.3	-	1.7	-
16	0.1	-	25.2	0.2	-	-	18.5	14.9	30.0	0.1	-	3.3	4.8	-	1.6	0.3	-	0.6	-
17	0.2	-	24.0	1.5	-	-	12.0	19.1	33.4	-	-	3.0	6.7	-	1.4	-	-	1.2	-
18	0.1	-	19.7	1.1	-	-	10.2	11.5	40.4	0.1	-	3.4	8.0	-	2.5	0.6	-	2.8	-
19	0.3	-	15.0	1.0	-	-	5.6	5.0	41.0	-	-	5.6	11.2	-	6.1	1.0	0.1	8.5	-
20	0.3	0.8	19.7	5.6	-	0.4	7.4	4.0	22.2	-	-	1.1	23.5	-	6.5	3.8	0.1	3.4	-
21	0.3	0.3	10.5	8.4	-	0.7	5.6	3.0	46.4	-	0.2	1.2	16.2	-	3.6	0.9	-	1.3	-
22	0.2	0.3	14.2	1.6	-	0.3	1.7	2.0	62.8	-	-	0.5	11.3	0.1	3.5	0.1	0.4	-	-
23	0.2	0.1	9.6	5.5	-	0.1	1.1	3.6	66.7	0.2	0.1	0.1	8.8	-	1.3	0.4	0.1	0.6	0.2
24	-	-	3.4	9.0	-	0.2	0.6	2.5	74.5	-	-	0.5	6.9	-	1.7	0.2	-	0.2	-
25	-	-	2.9	5.0	-	-	0.9	3.2	81.1	-	-	0.9	5.6	-	-	-	-	-	-
26	-	-	0.7	7.5	-	1.5	0.2	1.8	90.9	-	-	0.3	0.9	-	0.1	-	0.1	0.2	-
27	-	-	10.1	17.6	-	1.4	1.6	1.8	65.2	-	-	0.2	1.4	-	0.2	-	-	-	-
28	0.1	0.1	2.9	3.1	-	0.3	23.8	3.5	51.8	-	-	0.7	10.9	-	1.8	0.2	-	0.6	0.1
29	-	0.1	1.9	4.8	-	0.1	1.6	1.9	81.0	-	-	0.1	7.0	-	1.4	0.2	-	0.1	-
30	-	0.3	1.4	5.8	-	0.3	7.2	3.1	69.9	-	-	0.8	9.3	-	0.8	0.1	-	0.1	-
31	-	0.1	2.1	12.7	0.2	0.6	3.7	1.6	73.4	-	-	0.9	6.1	-	0.2	-	-	-	-
32	-	-	14.0	4.0	-	-	12.0	10.0	44.0	-	-	4.0	10.0	-	-	-	-	2.0	-

1. For explanation of abbreviations in next line, see preceding page.

TABLE 4. VERTICAL DISTRIBUTION OF SPECIES IN THE SPUR LAKE DEPOSIT.[2]

Coll.	SL	SS	PC	PV	VS	VT	AI	AU	FO	FD	GP	HS	HC	PE	PA	FP	PG	NB	SL	SA	VR
1	-	-	22.4	4.8	-	23.6	1.0	5.8	0.4	10.0	26.8	-	0.2	-	-	-	0.2	0.2	-	2.7	1.7
2	-	0.4	22.0	2.0	0.2	26.6	1.2	6.0	0.4	3.8	35.4	-	0.2	-	-	-	0.2	-	-	0.8	1.0
3	-	0.4	15.2	7.6	0.4	21.8	2.0	2.8	-	3.4	44.6	0.2	1.4	0.2	0.2	-	-	-	-	-	0.6
4	-	0.2	14.6	12.6	-	21.4	-	7.2	-	1.6	40.8	0.4	0.2	-	-	0.2	-	-	-	0.4	-
5	-	-	9.6	13.0	-	14.2	0.4	1.0	-	3.2	48.9	7.0	-	-	-	-	-	-	-	1.8	-
6	-	-	9.4	8.8	-	15.6	-	1.0	-	4.8	49.2	11.3	-	0.2	-	-	-	-	-	1.2	-
7	-	-	13.4	2.7	-	21.0	-	0.4	-	0.8	50.2	11.4	-	-	-	-	-	-	-	-	-
8	-	-	9.4	2.4	-	11.8	-	-	1.0	-	61.2	13.2	-	-	-	-	-	-	0.2	0.8	0.4
9	-	-	13.2	2.2	-	12.8	-	-	-	0.6	65.6	4.6	-	-	-	-	-	-	-	-	0.4
10	0.6	-	22.1	1.0	-	10.9	-	0.2	0.2	-	60.9	3.9	-	0.2	-	-	-	-	-	0.2	-
11	-	-	25.4	1.2	-	14.1	-	-	-	-	55.2	3.8	0.2	0.4	-	-	-	-	-	-	-
12	-	-	26.6	4.2	-	2.2	-	-	-	-	61.4	4.8	-	-	-	-	-	-	-	-	-
13	-	-	21.6	3.0	1.0	0.2	-	-	-	-	67.8	5.0	-	-	-	-	-	-	-	-	-
14	0.2	-	37.2	2.5	0.8	0.2	-	-	-	0.2	57.8	1.2	-	-	-	-	-	-	-	-	-
15	-	-	36.8	2.2	0.8	0.4	-	-	-	0.2	54.3	5.0	0.2	-	-	-	-	-	-	-	-
16	-	-	27.0	3.1	1.2	-	-	-	-	6.8	59.3	2.2	-	-	-	-	-	-	-	-	0.2
17	-	-	34.3	1.6	1.3	0.2	-	-	-	5.0	54.4	2.9	-	-	-	-	0.2	-	-	-	-
18	-	-	28.8	2.1	2.8	0.4	-	-	-	5.4	56.6	2.8	-	0.4	-	0.2	-	-	-	0.7	-

2. Explanation of abbreviations as for Table 3.

percent in collection 11 and continues to increase upward in the section until it reaches about 25 percent in the top 2 collections. Amnicola limosa and A. lustrica are absent from the lower half of the section but they do appear in small numbers in the upper part. Fossaria obrussa decampi appears in both the lower and upper parts of the section but is relatively rare in the middle. The remaining species occur randomly and in percentages less than 2 throughout the deposit. (See Table 4).

Mountain Deposit

In the Mountain deposit, seventeen species of non-marine Mollusca are present. (See Table 5). Four of the species are sphaeriid clams, four are gill-breathing fresh water gastropods, 7 are lung-breathing fresh water gastropods, and one is a terrestrial gastropod. Six species are abundant throughout the deposit and are considered indigenous. Three other species occur commonly enough to be considered native to the environment rather than intruders. The remaining seven species are uncommon, occurring mainly as less than 1 percent, and are probably not native to this environment. In this deposit the collections were made at 8 inch intervals. (See Plates X and XI).

The number of shells in the Mountain deposit remains fairly constant throughout, except for collections 12, 11, and 1. (See Table 5). In collections 12 and 11, the number of shells per 1000 milliliters of sediment is 1640 and 1765 respectively whereas in collections 10 through 2 the number of shells averages between 4000 and 6000. This may be accounted for by the fact that unit 1 is a pure marl with very little plant matter whereas units 2 to 4 are marl that contains an abundance of plant matter which is more favorable to the mollusks. In collection 1, unit 5, the number of shells declines sharply; this is because it is a unit of peat.

The six most abundant species Pisidium casertanum, Valvata tricarinata, Fossaria obrussa decampi, Gyraulus parvus, Helisoma anceps striatum, and Helisoma campanulatum remain fairly constant throughout the deposit with only minor changes in percentages. P. casertanum increases from 15 percent in collection 12 to 39 percent in collection 6 then decreases again to 15 percent in collection 2. Valvata tricarinata, however, decreases from 31 percent in collection 12 to 17 percent in collection 6 then increases to 29 percent in collection 1. These two species fluctuate together but in opposite directions which is probably caused by a changing environment. F. obrussa decampi increases somewhat from bottom to top, V. sincera decreases, but G. parvus, H. anceps striatum, and H. campanulatum remain fairly constant throughout. The uncommon species are Sphaerium lacustre, Sphaerium sulcatum, Pisidium variabile, Amnicola lustrica, Fossaria obrussa, Promenetus exacuous, Planorbula armigera, and Euconulus fulvus. Each of these species usually occurs as less than 1 percent of the total population, and occurs at random throughout the section. (See Table 5).

Waupaca Deposit

Twenty-one species of non-marine Mollusca are present in the Waupaca deposit. (See Table 6). The sphaeriid pelecypods are represented by 4 species, the gill-breathing fresh water gastropods by 4 species, the lung-breathing fresh water gastropods by 9 species and the terrestrial gastropods by 4 species. Of these, six species can be considered native throughout the life of the lake. Three species are common in various parts of the section and the remaining 12 species are generally rare throughout the deposit. (See Plates XII to XV).

The number of shells in the Waupaca deposit shows a large variation from collection to collection. (See Table 6). This variation is between 1600 and 5000 shells per 1000 milliliters of sediment. The quantity of shells does not seem to be controlled by lithology. Also, there

TABLE 5. VERTICAL DISTRIBUTION OF SPECIES IN THE MOUNTAIN DEPOSIT.[1]

Coll.	SL	SS	PC	PV	VS	VT	AI	AU	FO	FD	GP	PE	PA	HS	HC	PG	EF
1	-	-	10.8	0.4	2.5	29.2	12.1	0.9	-	21.1	16.4	-	-	3.4	1.2	1.4	-
2	-	-	14.9	-	0.4	26.6	5.4	2.1	-	23.1	18.9	0.1	-	3.1	2.9	1.8	-
3	0.1	-	19.8	-	1.4	17.0	2.5	1.4	-	27.1	20.0	-	0.1	2.2	5.2	2.9	-
4	0.1	0.1	44.3	0.4	0.6	13.8	3.3	0.7	0.2	13.3	12.5	-	-	2.1	3.9	4.6	-
5	0.4	-	36.3	0.1	0.5	20.5	3.0	0.9	-	6.6	18.6	-	-	2.6	3.9	6.2	0.1
6	0.3	-	38.8	0.1	0.3	17.5	4.2	0.9	-	6.6	17.1	-	0.1	1.5	4.5	7.9	-
7	0.9	-	34.6	-	1.2	23.1	3.9	0.1	-	6.4	16.0	-	-	3.1	3.7	6.8	-
8	0.9	-	34.4	-	0.5	27.9	1.9	0.2	-	1.6	15.2	0.1	-	6.4	3.3	7.2	-
9	1.1	-	30.9	0.3	1.4	24.0	1.4	0.4	-	8.6	14.2	0.1	-	9.0	3.4	4.9	-
10	0.9	-	27.1	0.8	1.2	27.6	1.9	0.1	-	8.0	18.3	0.2	-	7.5	2.0	3.9	-
11	1.0	-	22.8	1.1	3.9	29.6	1.1	-	-	8.8	17.2	-	-	9.5	1.9	2.8	-
12	4.7	0.2	14.7	0.7	4.2	31.4	2.9	-	-	9.9	15.0	-	-	10.1	1.2	4.1	-

1. Explanation of abbreviations as for Table 3.

EXPLANATION OF PLATES

Distribution of species in the White Lake deposit, collections 33 to 28. Each figure represents the percentages for the species present in the collection whose number follows the figure number. Species are represented by letters: a - *Amnicola lustrica*, b - *Amnicola limosa*, c - *Valvata tricarinata*, d - *Gyraulus parvus*, e - *Pisidium nitidum*, f - *Pisidium variabile*, g - *Fossaria obrussa decampi*, h - *Helisoma anceps striatum*, i - *Physa gyrina*, j - others.

PLATE II

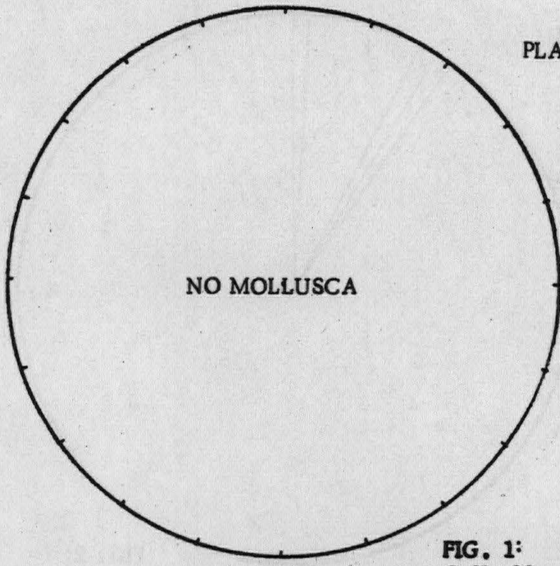


FIG. 1:
Coll. 33

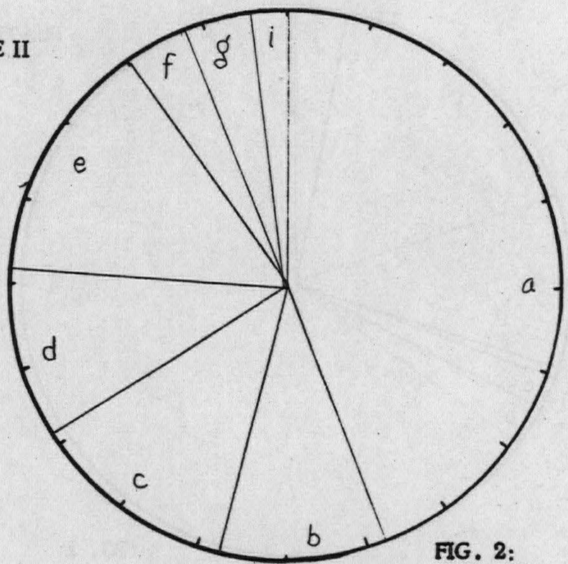


FIG. 2:
Coll. 32

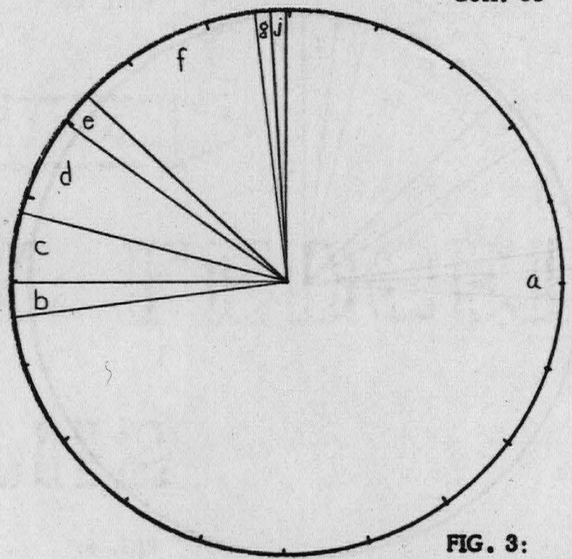


FIG. 3:
Coll. 31

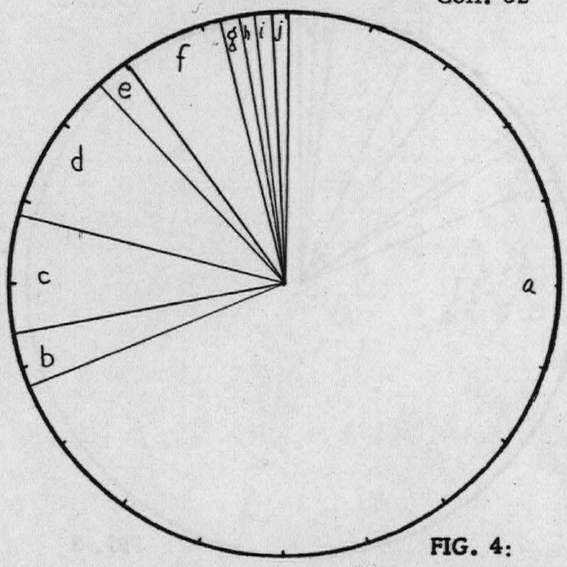


FIG. 4:
Coll. 30

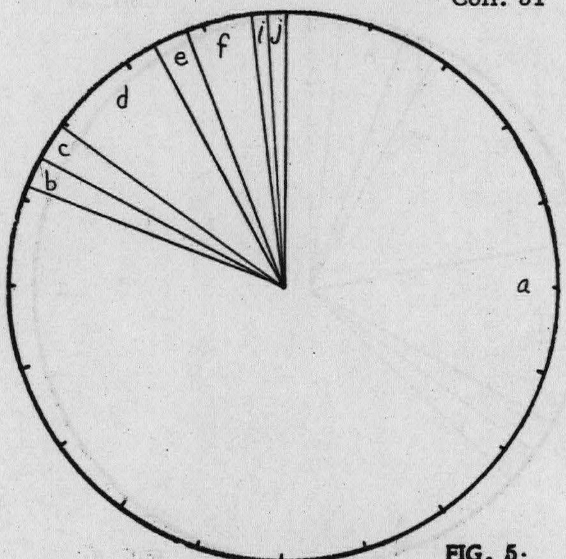


FIG. 5:
Coll. 29

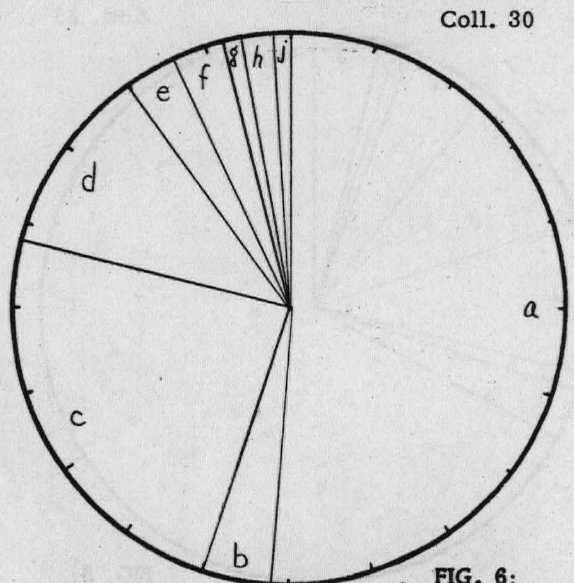


FIG. 6:
Coll. 28

PLATE III

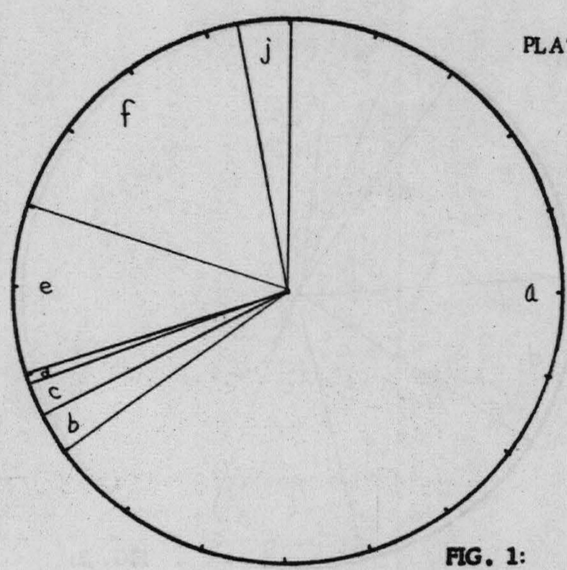


FIG. 1:
Coll. 27

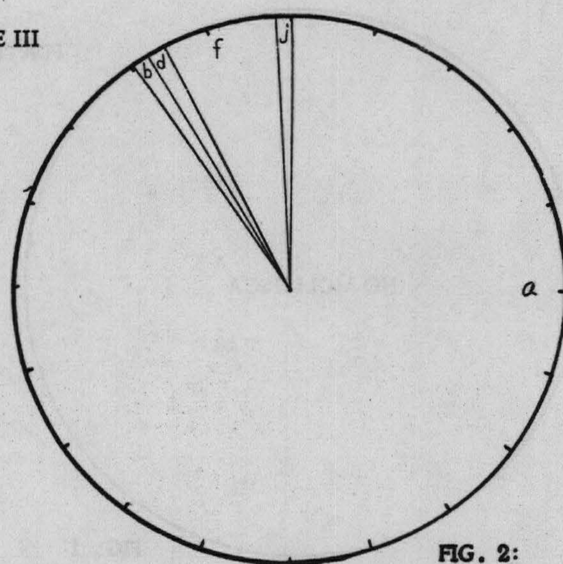


FIG. 2:
Coll. 26

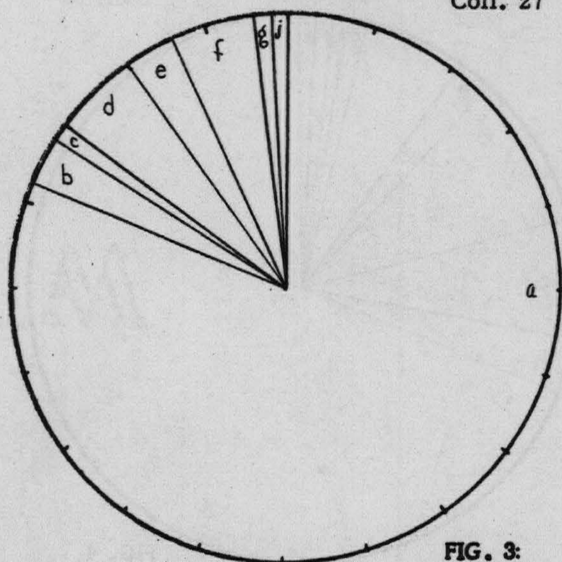


FIG. 3:
Coll. 25

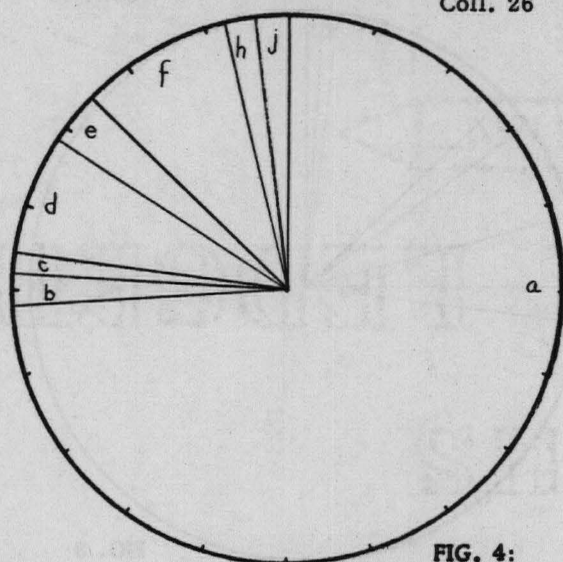


FIG. 4:
Coll. 24

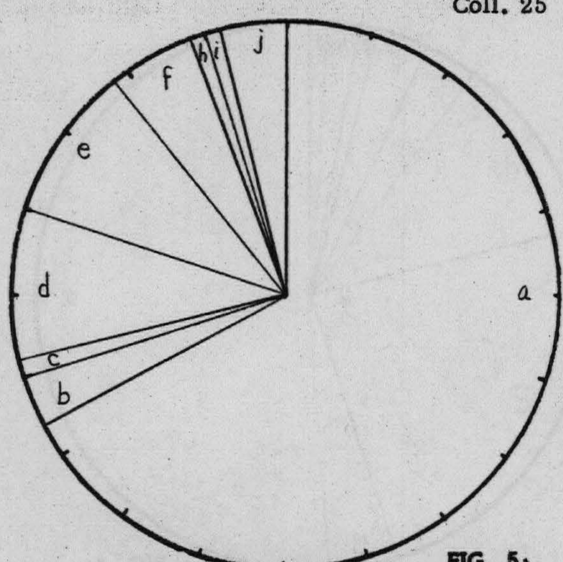


FIG. 5:
Coll. 23

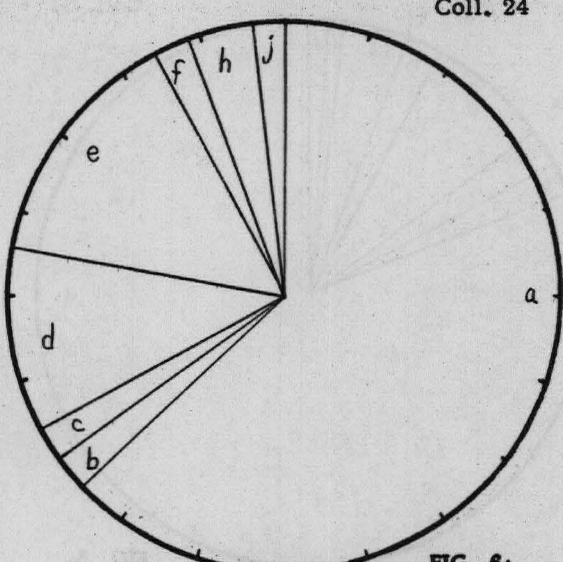


FIG. 6:
Coll. 22

is no change in the percentages of the species that can be connected to the change in quantity of shells.

The most abundant species present is Gyraulus parvus. This species ranges from 25 to 40 percent of population throughout, the higher percentages occurring in the upper part of the deposit. Fossaria obrussa decampi is the next most abundant species ranging from 10 to 35 percent and most abundant in the middle of the section, collections 20 to 14, where it approaches the same percentages as G. parvus. The other four species considered native occur in smaller numbers than the 2 above mentioned but they do occur constantly throughout. Pisidium casertanum is most abundant in the middle of the section through approximately the same interval as F. obrussa decampi. Valvata tricarinata and Helisoma anceps striatum are most numerous in the upper part of the section, whereas Amnicola limosa is most abundant in the lowest part.

The species Pisidium variabile, Amnicola lustrica, and Physa gyrina are common in certain parts of the section but generally rare elsewhere. P. variabile is common in the lower part of the section, A. lustrica in the middle part, and P. gyrina in the upper part. The 12 remaining species are rare, usually occurring as less than 4 percent. (See plates XII to XV).

Harmony Deposit

Seventeen species of mollusks are represented in the Harmony deposit. (See Table 7). Of these, one is a sphaeriid clam, 3 are gill-breathing fresh water gastropods, 10 are lung-breathing fresh water gastropods, and 3 are terrestrial gastropods. Only 2 species occur in sufficient quantity throughout the deposit to be called native, while one other species is common enough to be called native in the lower half of the deposit.

The number of shells per 1000 milliliters of sediment increases in general from the bottom to the top of the deposit. (See Table 2). It falls off drastically, however, in unit 3 which is the highest fossiliferous unit and a dark clay. The number of shells is quite constant between collection 29 at the bottom of the deposit and collection 16 in the marl unit, although there is a slight increase in the marl. The change from the silt of unit 1 to the marl in unit 2 did not have any significant effect on the number of shells. (See Table 2). From collection 15 through collection 7 there is an increase in shells followed by a small decrease in collection 6 and then the sharp decrease in collection 5 as the lithology changes from marl to clay. Collections 4 through 1 are unfossiliferous.

Fossaria obrussa decampi and Gyraulus parvus are the only two species that occur abundantly throughout the deposit. F. obrussa decampi is the most abundant species up to collection 19 in unit 2, averaging between 60 to 70 percent. (See Plates XV to XIX). From this point upward in the section it decreases, with only a small increase in collections 12, 11, and 10. Gyraulus parvus, however, starts out as 15 to 30 percent of the specimens and gradually increases toward the top of the deposit to where it is the most abundant species in collections 10 through 5, averaging from 70 to 85 percent of the total population. Lithology does not seem to be a factor in determining the abundance of these two species.

Pisidium casertanum can probably be considered a native in the lower half of the deposit. Although it never represents more than 10 percent of the population, its continued presence indicates it was native to this habitat.

Of the remaining species of freshwater and land gastropods, each represents about 2 percent or less of the population throughout the deposit. (See Table 7).

The land snails Succinea avara and Vertigo tridentata are most numerous in unit 1 and were probably washed in with the silt.

PLATE III. Distribution of species in the White Lake deposit, Collections 27 to 22. For explanation of letters, see Plate II, p. 43.

TABLE 6. VERTICAL DISTRIBUTION OF SPECIES IN THE WAUPACA DEPOSIT. [1]

Coll.	SL	SS	PC	PV	VS	VT	AI	AU	FD	GP	AC	PE	PA	HS	HC	FP	PG	SA	SL	GN	VR
8	-	-	3.6	1.2	-	18.7	3.8	-	13.5	39.1	-	-	-	8.0	-	-	3.1	4.0	-	4.0	0.3
9	-	-	3.4	0.4	-	18.4	4.9	0.1	10.0	37.4	-	0.3	0.1	10.7	-	-	8.9	2.0	-	2.5	0.4
10	-	-	2.6	0.2	-	16.3	4.0	0.9	25.1	34.9	-	-	-	8.4	0.6	-	6.1	0.1	-	0.3	0.1
11	-	-	8.5	0.4	-	7.7	5.1	2.7	26.6	36.8	-	-	-	8.8	0.5	-	4.9	0.1	-	0.3	-
12	-	-	14.5	0.3	-	7.2	3.2	0.7	19.8	38.8	-	-	-	10.8	0.8	-	2.8	0.5	-	0.1	0.1
13	-	-	20.9	0.2	-	5.6	1.9	0.1	18.9	40.7	0.1	-	-	8.3	1.3	-	1.4	0.1	-	0.5	0.1
14	0.3	-	12.3	1.9	-	7.2	2.0	1.7	28.2	39.8	-	-	0.3	4.2	0.2	0.2	0.6	0.1	0.2	-	0.1
15	0.4	-	17.2	1.6	-	6.1	0.8	1.7	31.5	35.5	-	-	-	3.2	0.6	-	0.9	0.2	0.1	-	-
16	0.1	-	17.1	0.7	-	2.5	1.5	0.5	34.5	33.3	-	-	-	8.8	-	-	0.2	-	-	-	-
17	-	-	12.4	1.0	-	7.2	2.5	2.0	35.8	24.9	-	-	-	12.4	-	-	-	-	-	-	-
18	0.1	-	15.5	9.3	0.1	10.1	5.1	10.2	19.3	23.8	-	-	-	5.7	0.4	0.2	0.2	-	-	-	-
19	0.2	-	22.1	6.9	-	3.4	3.4	2.6	31.3	25.8	-	0.1	-	3.2	0.5	-	0.2	-	-	-	-
20	-	0.2	18.7	5.7	-	5.4	11.8	6.8	22.8	25.1	-	-	-	3.3	0.2	-	-	-	-	-	-
21	-	0.3	4.7	19.4	0.2	9.9	19.6	4.5	14.7	25.1	-	-	-	1.6	-	-	-	-	-	-	-
22	-	0.5	1.7	18.5	1.1	4.1	19.7	-	18.6	33.9	-	-	-	1.6	-	-	-	0.1	-	-	0.2
23	-	0.6	3.7	19.5	3.1	4.9	15.6	-	17.9	32.7	0.1	-	-	1.9	-	-	-	-	-	-	-
24	-	0.5	2.0	16.9	4.7	6.9	8.9	-	24.6	31.6	-	-	-	3.9	-	-	-	-	-	-	-
25	-	0.2	2.9	12.4	0.9	7.8	16.8	-	24.9	30.8	-	-	-	2.8	0.2	-	0.1	-	-	0.1	-
26	-	-	3.7	14.8	-	6.6	10.1	-	30.1	30.2	0.2	-	-	3.1	0.4	-	0.2	-	-	0.1	-

1. Explanation of abbreviations as for Table 3.

TABLE 7. VERTICAL DISTRIBUTION OF SPECIES IN THE HARMONY DEPOSIT.[1]

Coll.	PC	VS	VT	AI	SP	FO	FD	GP	AC	HS	HC	FP	PG	AH	HP	SA	VR
5	-	-	-	-	-	-	26.0	73.9	-	-	-	-	-	-	-	-	-
6	0.1	-	-	-	-	1.2	26.5	72.1	-	-	-	-	-	-	0.1	-	-
7	-	-	-	-	-	0.2	14.4	85.1	-	-	-	-	0.2	-	-	-	-
8	0.1	-	-	-	-	-	18.3	81.0	-	-	-	-	0.3	0.2	-	-	-
9	-	-	-	-	-	-	30.4	69.0	-	-	-	-	0.4	-	-	-	0.1
10	0.5	-	-	-	-	-	51.0	47.4	-	-	-	-	0.5	0.1	-	-	-
11	0.2	-	-	-	-	-	56.8	42.9	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	56.0	43.8	-	-	0.1	-	-	-	-	-	-
13	0.4	-	-	-	-	-	46.0	53.2	-	-	0.1	-	0.2	-	-	-	-
14	0.9	-	-	-	-	-	36.4	60.6	0.1	-	0.2	-	1.7	-	-	-	-
15	4.2	-	-	-	-	-	41.0	53.0	-	0.2	0.5	-	0.5	0.2	-	-	-
16	7.9	-	0.1	-	-	0.1	36.6	53.4	-	0.7	0.4	0.1	0.3	0.1	-	-	-
17	4.2	-	0.5	0.1	-	-	43.2	50.9	-	0.8	-	-	0.3	0.1	-	0.1	-
18	9.4	-	1.7	-	-	-	39.2	48.0	0.1	1.0	-	-	0.2	-	-	-	-
19	6.2	-	-	-	-	-	48.9	43.2	-	1.6	-	-	-	-	-	-	-
20	4.3	0.2	0.2	-	-	-	64.1	31.5	-	0.2	-	-	-	-	-	-	-
21	2.9	-	0.2	-	0.1	0.1	58.2	38.3	-	0.3	-	-	-	-	-	-	-
22	2.7	-	0.2	-	0.2	-	71.5	24.8	-	-	-	-	-	-	-	-	0.4
23	3.4	-	0.3	-	-	0.8	72.3	22.2	-	-	-	-	-	-	-	0.6	0.2
24	4.7	-	0.4	-	-	-	65.9	27.6	0.1	-	-	-	-	-	-	0.7	0.3
25	3.1	0.2	-	-	-	1.0	62.5	30.2	-	0.3	-	-	-	-	-	2.4	0.2
26	5.8	-	-	-	0.8	0.8	53.8	34.2	-	-	-	-	0.2	-	-	2.6	1.6
27	3.9	-	-	-	-	0.5	74.4	20.0	-	-	-	-	-	-	-	1.2	0.2
28	3.4	-	-	-	-	3.4	76.4	15.5	-	-	-	-	0.3	-	-	0.9	-
29	-	-	-	-	-	3.0	65.0	31.0	-	-	-	-	-	-	-	-	-

1. Explanation of abbreviations as for Table 3.

PALEOECOLOGY

General Statement

One of the most important aspects of this study is the paleoecology or determination of former environment. This can be accomplished best when a large number of well preserved specimens are used which represent essentially all of the individuals in the section. The former environment can not be confidently reconstructed using just one or two species, but must be reconstructed from data gathered from the majority of the assemblage. In using data from an assemblage, accurate quantitative information must be obtained in order to give each species its proper perspective.

In the study of Pleistocene paleoecology a great deal of information can be obtained from living species and assemblages. All of the species represented in this study have living representatives, of the same species or very close relatives. It can be reliably assumed that a species in the past required the same type of habitat that its living representatives do at present. In a quantitative study, the species that occur most abundantly in a given collection are considered to have been native to the environment in which they lived. Those that are uncommon are probably intruders from another environment which may be in close proximity, and those that are rare are probably intruders which were brought into the environment by some outside agent.

Each deposit was sampled at 2-inch intervals except the Mountain deposit which was sampled at 8-inch intervals. It was shown in the chapter on the composition of faunas that both the number of shells and the percentages of species can change markedly in such small intervals. These changes for the most part are not due to changes in lithology, so it might be assumed that they are due to slight changes in environment.

In the following pages an attempt has been made to reconstruct the paleoecology of each deposit. A synopsis was then made for the area covered by this report by comparing the five deposits. The comparison attempts to bring out any similarities or differences that might occur which would reflect a change in environment for the whole area.

White Lake Deposit

The White Lake deposit is lacustrine and consists of marl, peat, and sand. The lacustrine origin of these sediments is proved by the abundance of fresh water Mollusca. The alternating layers of marl and peat in the section indicate that the lake environment was not stable throughout its existence, but that it fluctuated from a shallow swampy environment in which peat accumulated to a deeper open water environment in which the marl was deposited. The lowest 8 inches of the deposit is a well-compacted peat which contains no shells. This was probably formed under very swampy conditions in dense vegetation. (See plates II to VI).

The first shells appear in collection 32, also a peat, but one that was deposited under shallow water. The species that first appear abundantly in the deposit are Pisidium nitidum, Valvata tricarinata, Amnicola limosa, A. lustrica, and Gyraulus parvus, all

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PLATE IV. Distribution of species in the White Lake deposit, collections 21 to 16. For explanations of letters, see explanation of Plate II, page 42.

PLATE IV

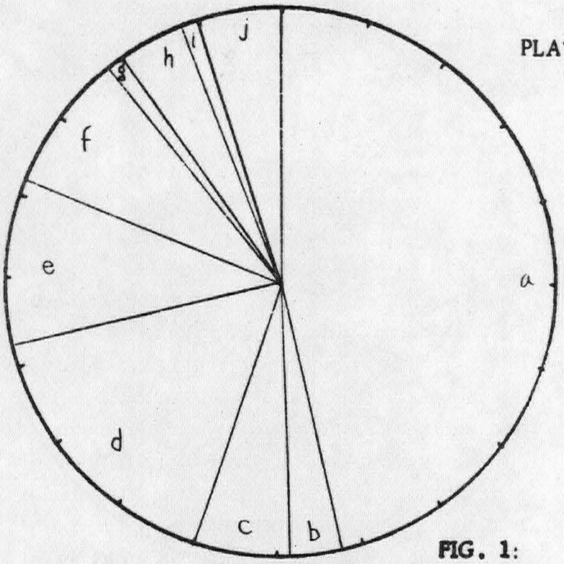

FIG. 1: Coll. 21

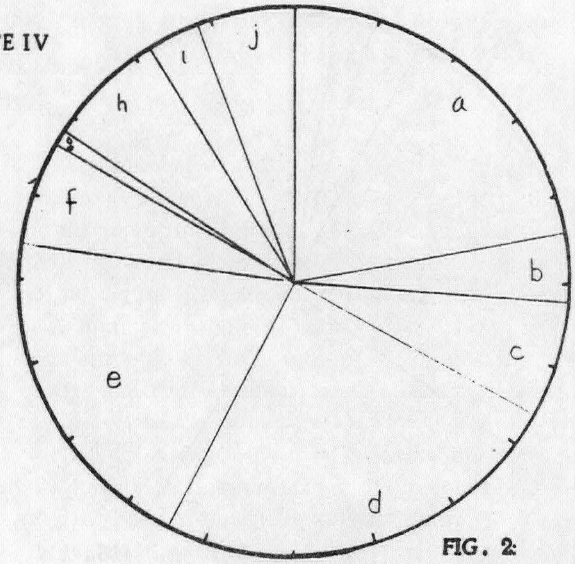

FIG. 2: Coll. 20

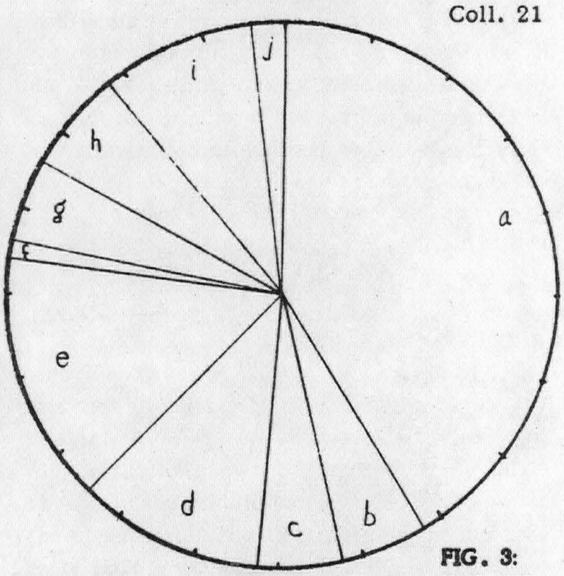

FIG. 3: Coll. 19

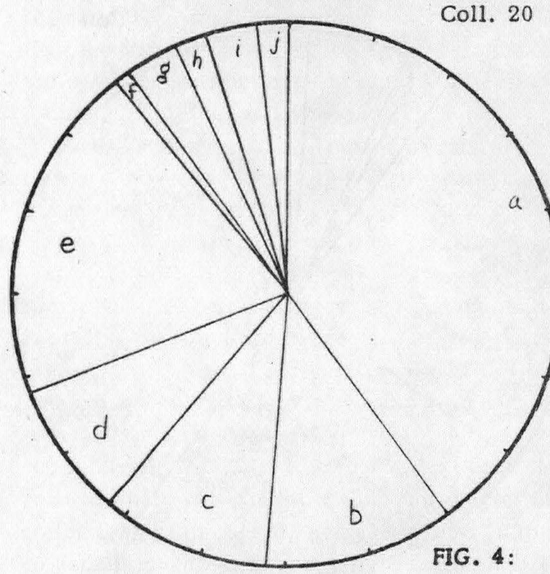

FIG. 4: Coll. 18

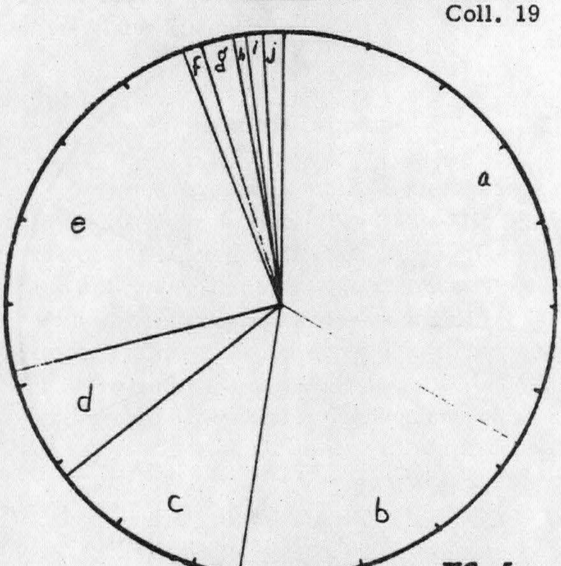

FIG. 5: Coll. 17

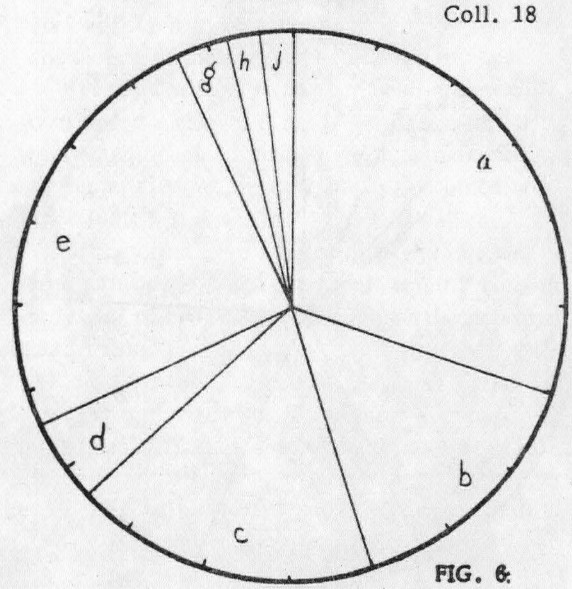

FIG. 6: Coll. 16

PLATE V

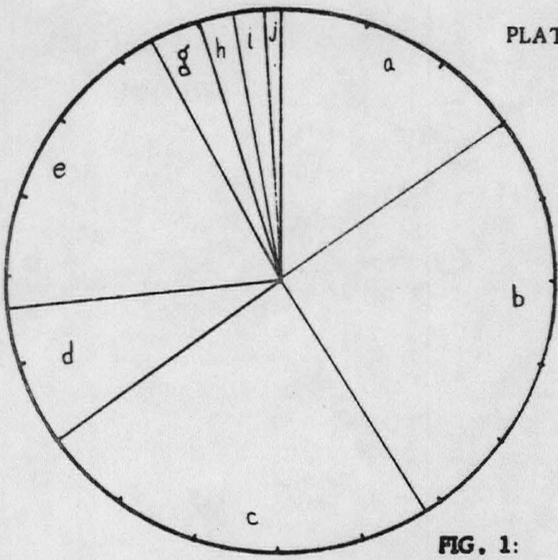

FIG. 1:
Coll. 15

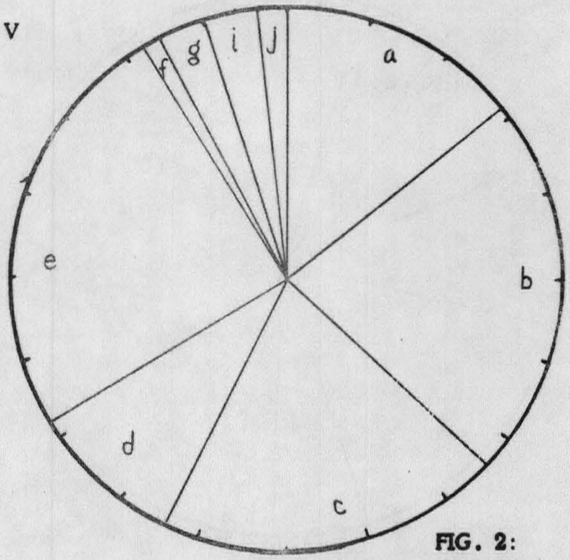

FIG. 2:
Coll 14

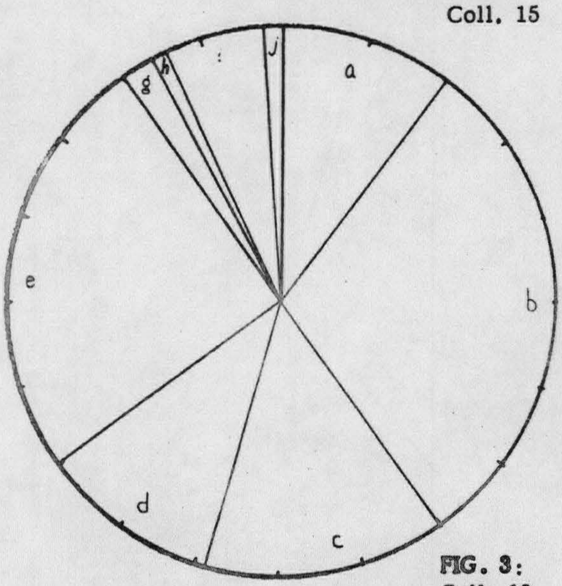

FIG. 3:
Coll. 13

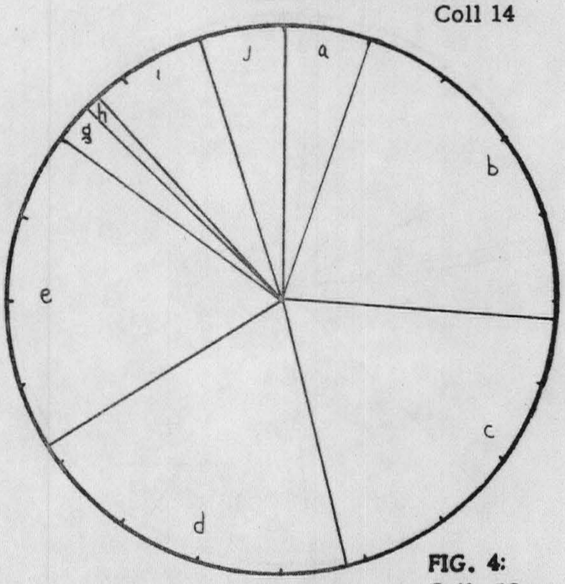

FIG. 4:
Coll. 12

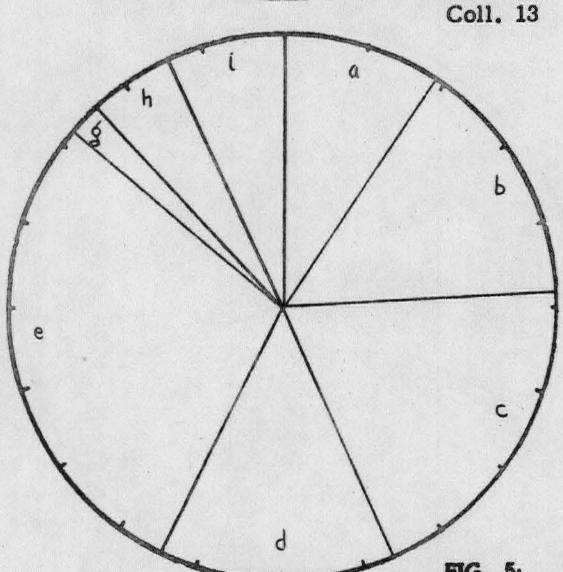

FIG. 5:
Coll. 11

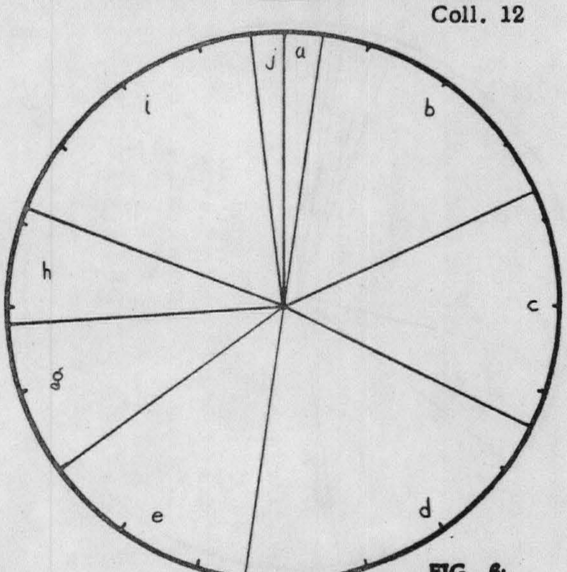

FIG. 6:
Coll. 10

capable of living in shallow water with abundant vegetation. The number of shells in this lowest fossiliferous unit was quite small. In collection 31, the first marl unit, the quantity of shells increased sharply and this was due largely to an increase in Amnicola lustrica which makes up 73 percent of the individuals. Most of the other species are rather uncommon except Pisidium variabile. (See Plate II). The environment at this time was probably shallow, quiet water with abundant vegetation. A. lustrica continues to dominate through the marl of units 4 and 5, while the other species remain uncommon except for V. tricarinata which increases to 24 percent in collection 28. The environment apparently remained the same as in unit 3, shallow quiet water with vegetation.

The peat of unit 6 indicates that the lake became very shallow and dense in vegetation with a halt in the marl deposition. The percent of A. lustrica increases slightly while the percent of P. nitidum and P. variabile increase significantly. The other species remain uncommon and the quantity of shells decreases sharply. Marl deposition is resumed in unit 7 with the deepening of water. The percent of A. lustrica increases to 90 and the abundance of the two species of Pisidium decreases. (See Plate III). The great abundance of A. lustrica must indicate a very favorable environment for this species; abundant vegetation rich in diatoms, in water approximately 2.4 to 3.0 meters in depth. The quantity of shells returns to normal abundance. Unit 8 is a return to the peat of shallow water environment with no significant changes in the mollusks. The sand of unit 9 was probably washed or blown into the lake from the nearby sandy ridges. This probably took place when the lake was shallow because the sand contains no shells, and the only shells in the collection are found in the small patches of peaty clay that occur in the sand. No significant changes in percentages of the species accompany the change in lithology, so it can probably be assumed that the shells are from the unit below.

Above the sand are 3 units of marl, collections 23 to 8, indicating a return to a normal lacustrine environment. The quantity of shells increases sharply from the low in collections 25 and 24. A change in the percentages of species begins to take place here. From unit 10 upward the percentage of A. lustrica begins to decrease, while the percentages of P. nitidum, V. tricarinata, A. limosa, F. obrussa decampi, and G. parvus also increase in number. All of these species prefer shallow quiet water with vegetation similar to the environment that prevailed in unit 4. In unit 11, A. lustrica declines sharply and G. parvus and P. variabile increase. The marl in this unit is very clayey indicating an influx of mud accompanied by an increase in vegetation. Throughout unit 12, the other species continue to increase in number, while A. lustrica decreases. Most of the species present in this unit prefer a shallow water environment. Although there is a significant decrease in A. lustrica, it is accompanied by an increase in A. limosa which prefers the same habitat. The one species that might indicate a change is V. tricarinata; it can live in shallow water but prefers a deeper water habitat. This does not mean a great deepening but possibly from 2 or 3 feet to 7 or 8 feet.

From the marl of unit 12 there is a change to peat in unit 13. This, however, may have been accumulated in deeper water than the other units

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PLATE V. Distribution of species in the White Lake deposit, collections 15 to 10. For explanation of letters, see explanation of Plate II, p. 42.

of peat. The decline in number of shells is less and the deeper water species V. tricarinata reaches its greatest abundance here. The other species are not affected too greatly. Marl is again deposited for a short time in unit 14 before the lake comes to an end in unit 15. There are no significant changes in unit 14, the two species of Amnicola increase slightly and G. parvus decreases. Again, this indicates shallow water with vegetation. The open water of the lakes was probably cut off by encroaching vegetation which covers the marl everywhere as a black peaty muck.

The type of lithology and the species present indicate that this deposit was a small shallow pond or lake. The section studied was close to the edge of the lake. Marl was deposited when the water was a few meters deep and peat when the water was only a few inches deep. The species present indicate an environment of shallow quiet water with moderate to dense vegetation. The pH of the water in the lake was between 7 and 8 because the species Amnicola lustrica, Valvata tricarinata, and Gyraulus parvus can not generally tolerate water with a pH below 7. The bottom conditions were soft, particularly when the marl was being deposited. The sediments indicate that the depth of water fluctuated a number of times and that the lake ended when vegetation took over and swampy conditions prevailed. The swamp gradually dried up and a forest grew over the area.

Spur Lake Deposit

The marl of Spur Lake was deposited in a lacustrine environment probably very similar to the one that exists there today. Although Spur Lake has shrunk somewhat, it is still about 80 percent of its original size. (See Figure 3). About half of the marl in the deposit is now exposed and the other half is under water. Marl deposition continues in the lake. The marl is homogeneous throughout and is all included in one unit. Only the top 36 inches of the section was sampled and studied.

The quantity of shells from collection 18 to collection 5 is quite low but it does steadily increase through this interval. Only two species can be considered native in the 7 lowest collections, Pisidium casertanum and Gyraulus parvus. (See Plates VII to IX). G. parvus is the more abundant, averaging between 55 and 65 percent of the individuals. Its habitat is that of small quiet bodies of water with abundant vegetation. The depth of water was probably about 1 to 2 meters. P. casertanum can live in the same habitat and is often found in small lakes in quiet water. In the same interval V. sincera and F. obrussa decampi appear to be intruders from a nearby habitat. They both occur in small numbers, but V. sincera is a deep water species from about 3 meters or more and F. obrussa decampi is a shallow water and mud flat species. (See Plate VII). It appears that the marl between collections 18 to 12 was deposited in water about intermediate in depth, 1 to 2 meters, with moderate vegetation. The occurrence of V. sincera means that it is an intruder from the deeper part of the lake and that F. obrussa decampi is an intruder from the shallow part of the lake near shore. Both of these species are gone, however, before the end of this interval.

From collection 11 to the top of the deposit other species become more common. V. tricarinata increases from 2.2 percent in collection 12 to 14 percent in collection 11, to approximately 25 percent near the top. (See Plate [illegible]

PLATE VI. Distribution of species in the White Lake deposit, collections 9 to 4. For explanation of letters, see explanation of Plate II, p. 42.

PLATE VI

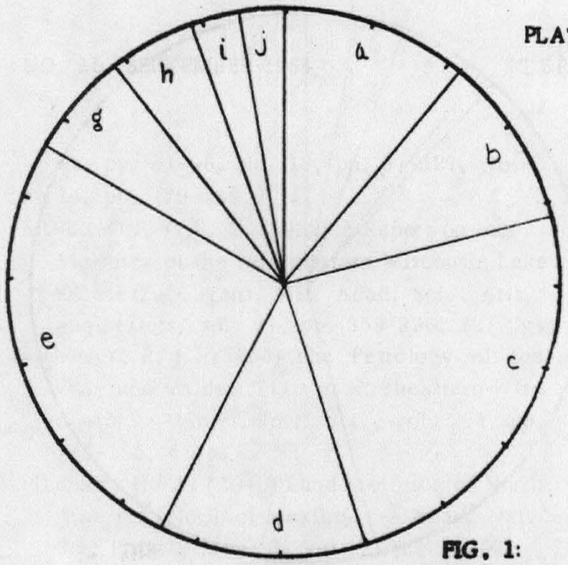

FIG. 1:
Coll. 9

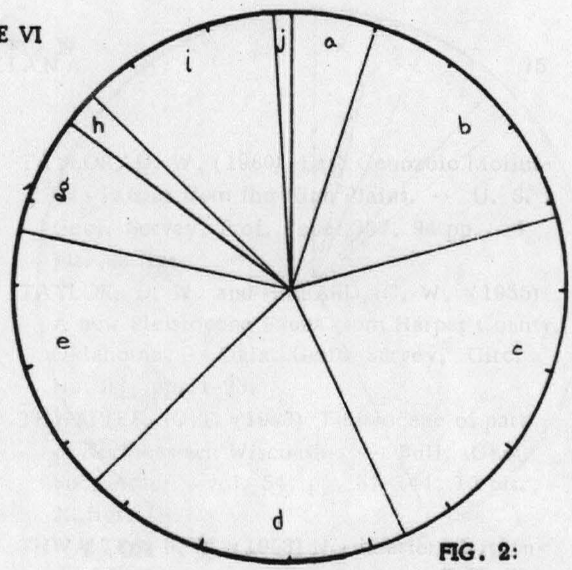

FIG. 2:
Coll. 8

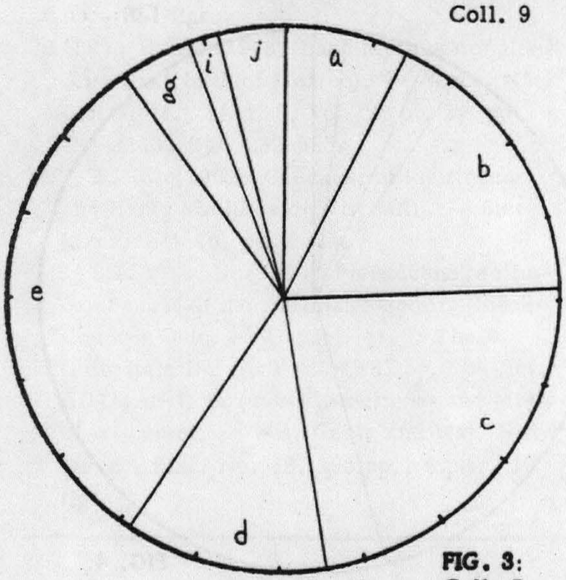

FIG. 3:
Coll. 7

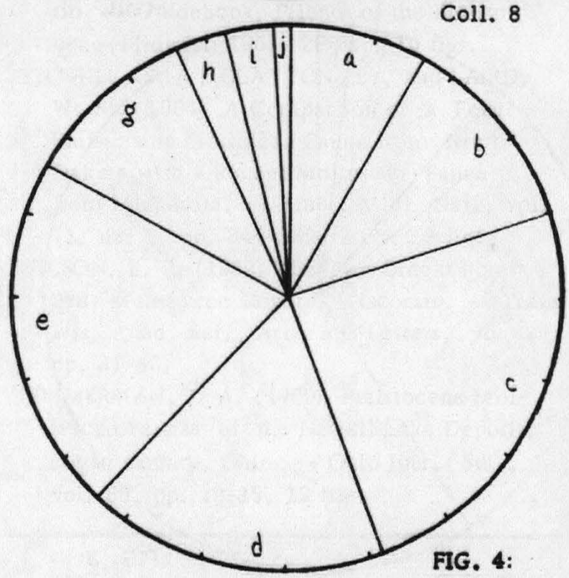

FIG. 4:
Coll. 6

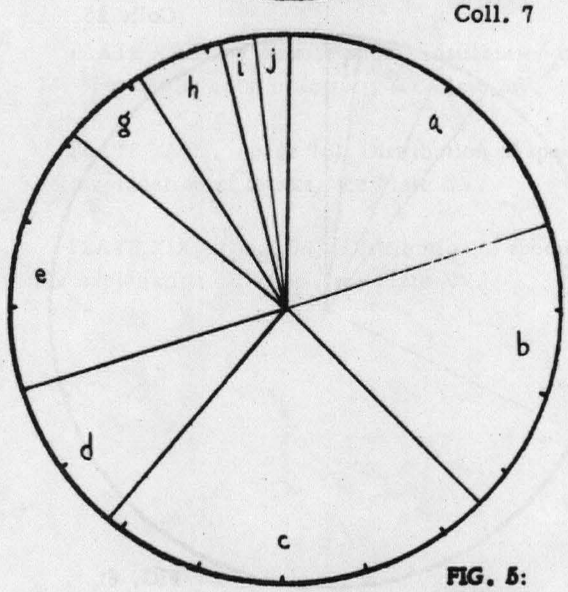

FIG. 5:
Coll. 5

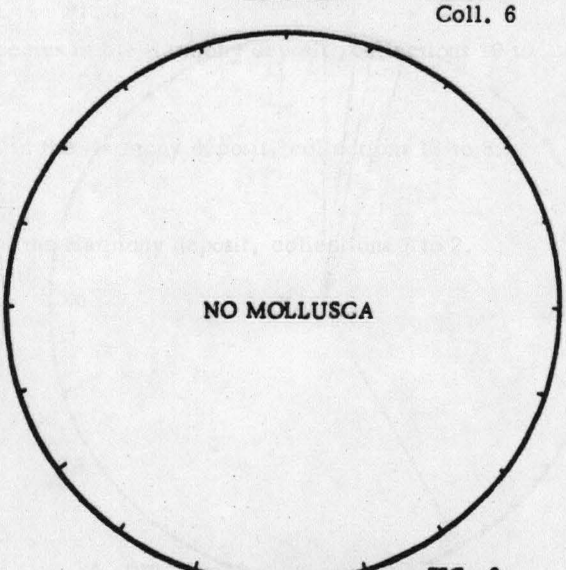

FIG. 6:
Coll. 4

PLATE VII

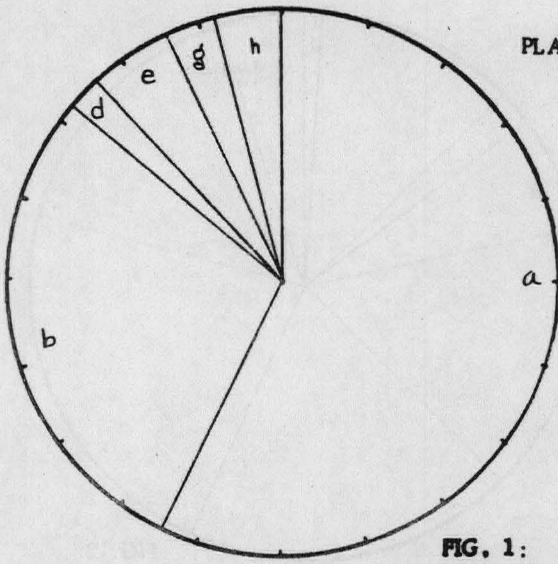

FIG. 1:
Coll. 18

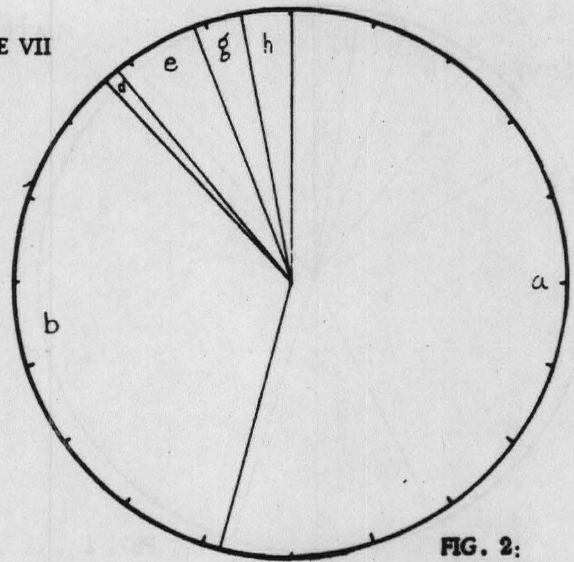

FIG. 2:
Coll. 17

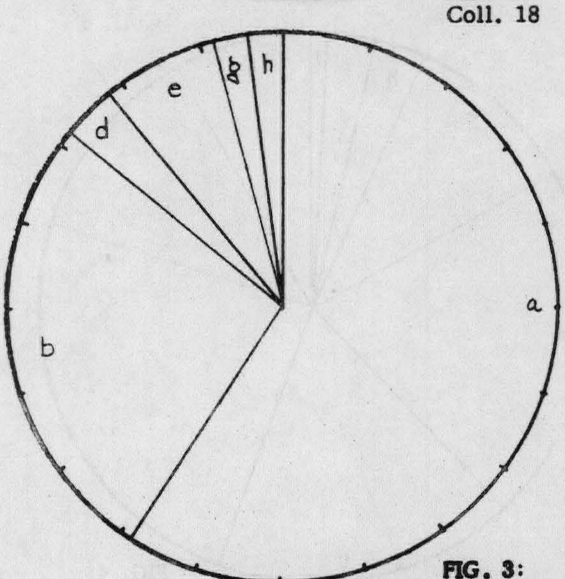

FIG. 3:
Coll. 16

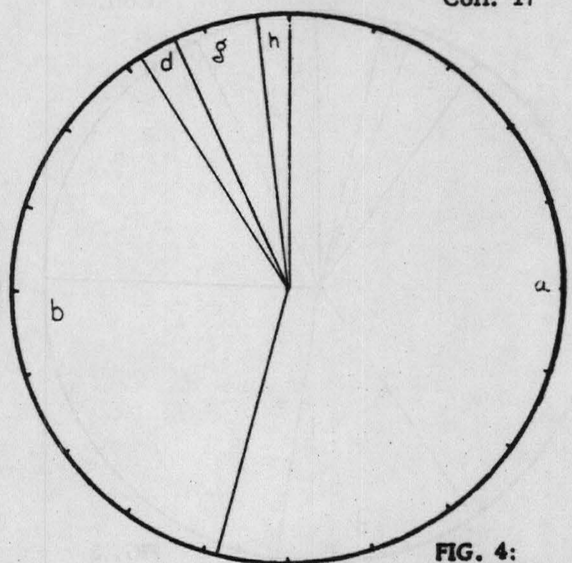

FIG. 4:
Coll. 15

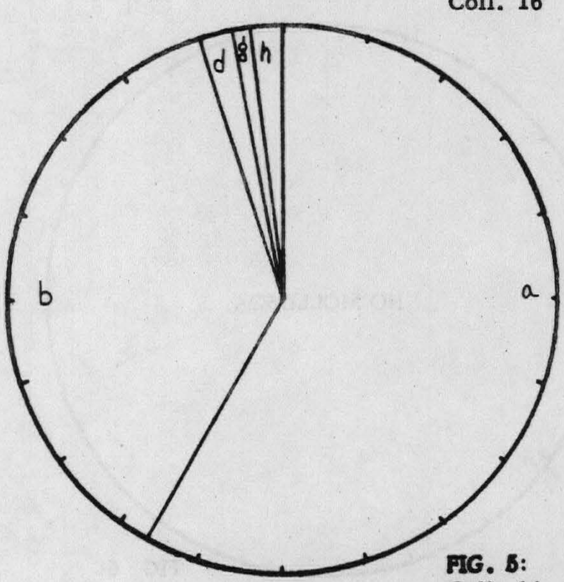

FIG. 5:
Coll. 14

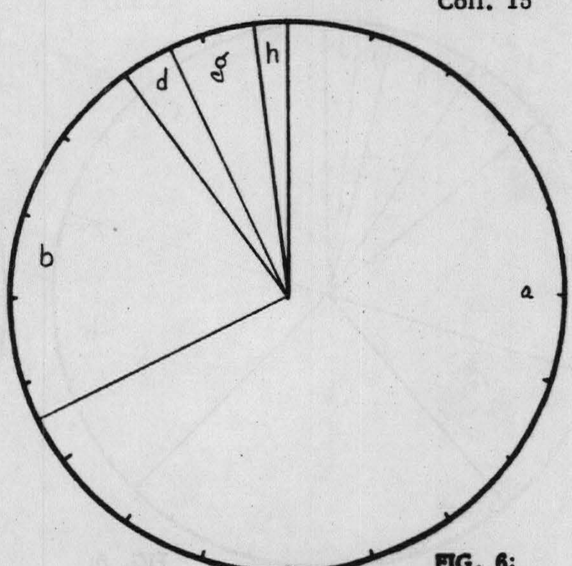

FIG. 6:
Coll. 13

VII). This sharp increase then gradual increase toward the top indicates that the water was probably slowly getting deeper. A decrease in this interval is shown by G. parvus and P. casertanum which might also indicate a slight deepening of water. The species of Amnicola are late comers to this environment and do not become common until the last 4 collections. F. obrussa decampi, which is nearly absent in the middle of the section, reappears near the top. The presence of Amnicola lustrica and F. obrussa decampi would imply that the water was not too deep, probably only 2 or 3 meters, as in the lower part of the section. If an increase in depth caused the increase in number of V. tricarinata, it appears to have become somewhat more shallow again in the top six collections. This is possible because V. tricarinata can live in the same habitat as G. parvus which is still the most abundant species in the deposit.

One of the most important species in terms of ecology is Helisoma anceps striatum. This species was quite common in the lake up to collection 4. (See Plates VII to IX). The importance of the form striatum is that it is characteristic of cold waters. It has been found living in a few cold water lakes of Minnesota and Wisconsin, but farther south it is known only in the fossil state. F.C. Baker (1935, p. 271) records this species from North Star and Little North Star lakes in northern Minnesota. He states that "The race is more abundant in the north and its presence as a fossil farther south probably indicates colder water then than now." The near absence of this form in the top 4 collections may indicate warmer water at this time due to a climatic change. Other evidence that might indicate a warming trend is the great increase in number of shells in the top 4 collections. It would thus seem that the depth of water, bottom conditions, and vegetation, probably remained fairly constant throughout the time when the marl was deposited, but that the climate became warmer as evidenced by the disappearance of H. anceps striatum and the great increase in abundance of the other species.

The number of land snails in the deposit tends to increase toward the top. These species were undoubtedly washed in from the area around the shore of the lake.

In summary, the marl of this deposit was precipitated in a small lake such as is now present at the site. The water was probably one to 2 meters in depth. There may have been a slight increase in depth in the middle of the section with a corresponding decrease near the top. The bottom was soft with moderate vegetation. The water was cold through most of the history of the lake but became warmer towards the end.

The species present indicate that the pH of the water was between 7 and 8.

Mountain Deposit

The Mountain deposit represents an accumulation of marl and peat that was deposited in a lacustrine environment. The marl contains abundant shells of fresh water mollusks which indicate lacustrine origin. The 4 lowest units are all marl of varying purity which were deposited in a lake environment. The top 2 units are peat, unit 5 fossiliferous and unit 6 unfossiliferous, which show that the lake became filled with vegetation until swampy conditions prevailed, apparently for a long time. This deposit was sampled at 8-inch intervals.

PLATE VII. Distribution of species in the Spur Lake deposit, collections 18 to 13. Each figure represents the percentages for the species present in the collection whose number follows the figure number. Species are represented by letters: a - Gyraulus parvus, b - Pisidium casertanum, c - Valvata tricarinata, d - Pisidium variabile, e - Fossaria obrussa decampi, f - Amnicola lustrica, g - Helisoma anceps striatum, h - others.

Collection 12 in unit 1 is represented by a very pure white marl with little vegetation, in which the first shells appear. The species in the lowest unit represent a rather complete assemblage. (See Plates X and XI). The most abundant species is V. tricarinata which makes up about 30 percent of the individuals. P. casertanum and G. parvus are each about 15 percent, and F. obrussa decampi and H. anceps striatum each make up about 10 percent of the total. The kinds and abundance of species indicate that the former lake was fairly shallow, 1 to 2 meters, contained sparse vegetation on a soft bottom, with cold water.

From collection 11 in unit 1 to collection 6 in unit 3, the abundance of V. tricarinata declines while P. casertanum increases. G. parvus remains approximately the same throughout, but both F. obrussa decampi and H. anceps striatum decline. The quantity of V. sincera, which is common near the bottom of the deposit, decreases upward. The change in the percentages of individuals seems to indicate that the water was becoming somewhat more shallow. (See Plate XI). The vegetation increased until it was moderate. The water probably was becoming warmer as evidenced by the decline in H. anceps striatum. The bottom was quite soft.

Near the top of unit 3, in collections 5 to 3, the water was shallow and vegetation grew moderately. The site of the section appears to be near shore because F. obrussa decampi increases rapidly here implying very shallow water and mud flats. All of the other species present are quite capable of living in this environment. Physa gyrina, which occurs commonly in this deposit, is often found on vegetation, such as the underside of lily pads.

The change of environment which accompanied the transition from marl to peat between units 4 and 5 did not have any great effect on the relative percentages of the species present. (See Plate XI). It did, however, have an effect on the total number of individuals, for there was a great decline from 4000 to 1150 shells per 1000 milliliters of sediment. During the deposition of material in unit 5, the water was very shallow, probably less than a meter, and the vegetation was abundant. As the lake filled with vegetation and sediment a bog environment took over in which the mollusks could not survive.

The marls of the Mountain deposit were laid down in a small shallow lake. The depth of water at the site of the sampled section probably ranged from about 0.5 to 2 meters. The bottom was soft and the amount of vegetation increased as the lake became older. The mollusks that lived in the lake preferred water that was neutral or slightly alkaline, pH between 7 and 8.

Waupaca Deposit

Seventeen species of fresh water mollusks occur in the Waupaca deposit indicating that the sediment was deposited in a lacustrine environment. The most abundant species, of the 11 that occur in the lowest collection, are Gyraulus parvus, Fossaria obrussa decampi, Pisidium variabile and Amnicola limosa. (See Plate XII). The two species F. obrussa decampi and G. parvus are the most abundant, each making up about 30 percent of the individuals. Both of these species require shallow water, the former shallow water and a mud flat environment, and the latter shallow

PLATE VIII. Distribution of species in the Spur Lake deposit, collections 12 to 7. For explanation of letters, see Plate VII.

PLATE VIII

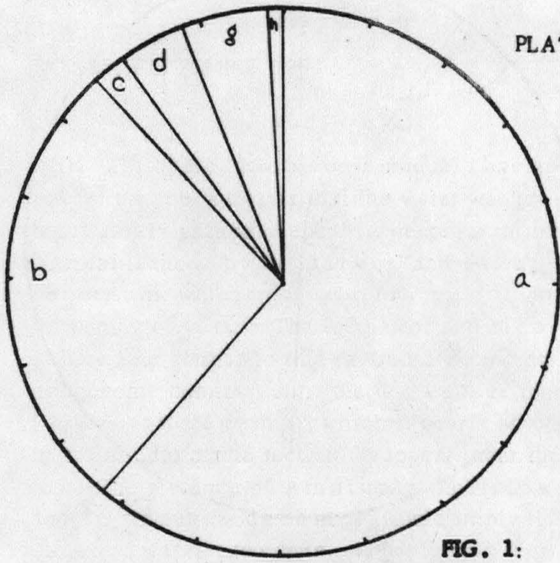

FIG. 1:
Coll. 12

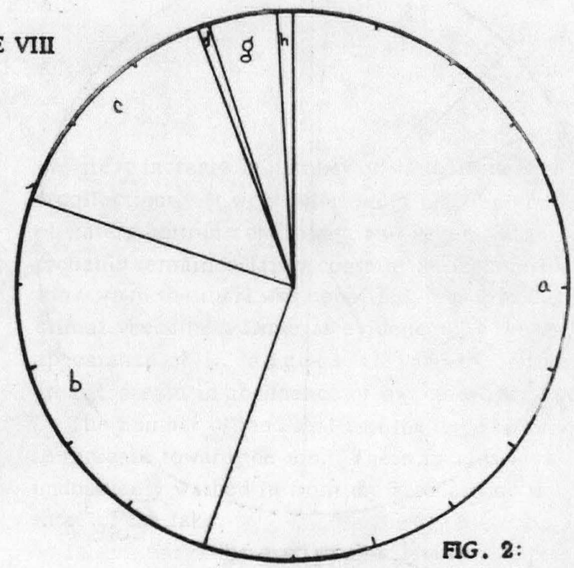

FIG. 2:
Coll. 11

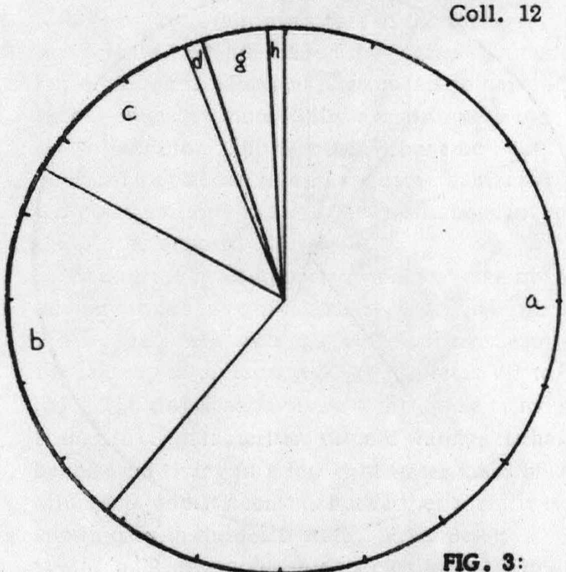

FIG. 3:
Coll. 10

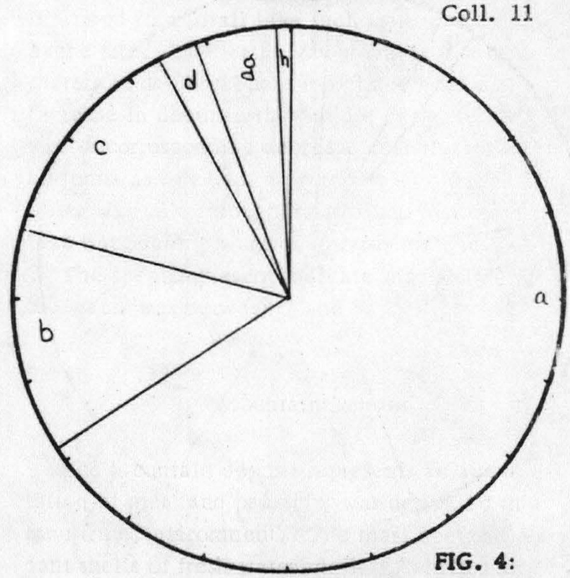

FIG. 4:
Coll. 9

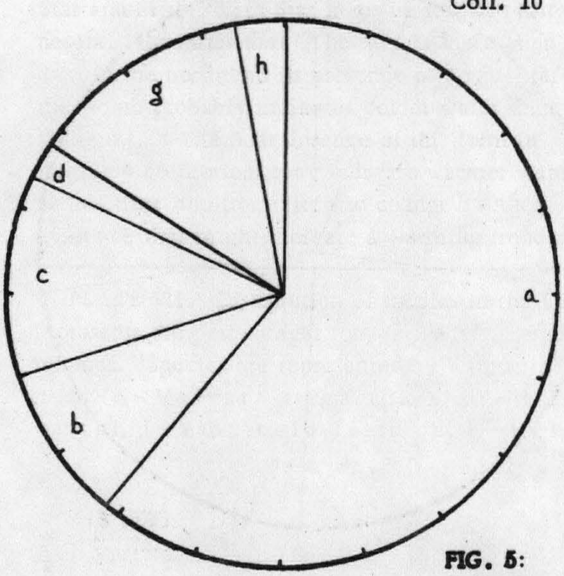

FIG. 5:
Coll. 8

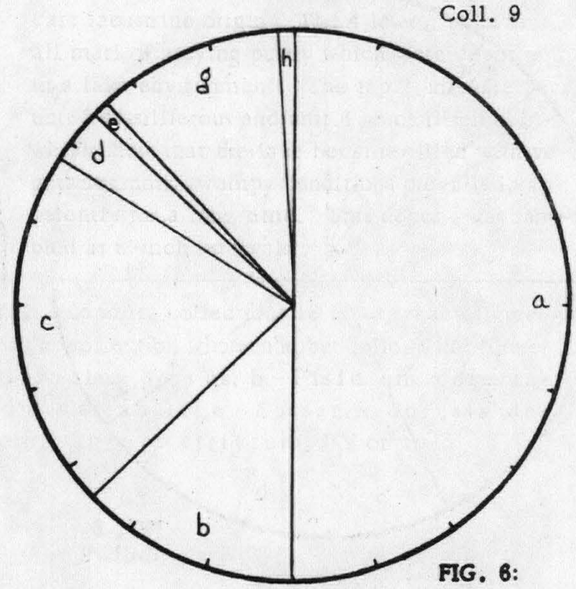

FIG. 6:
Coll. 7

PLATE IX

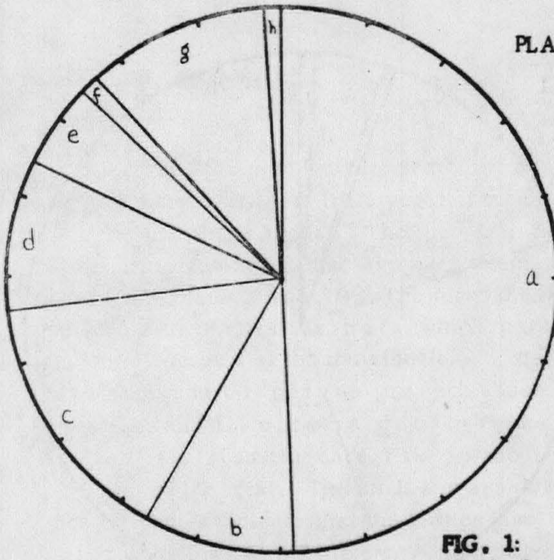

FIG. 1: Coll. 6

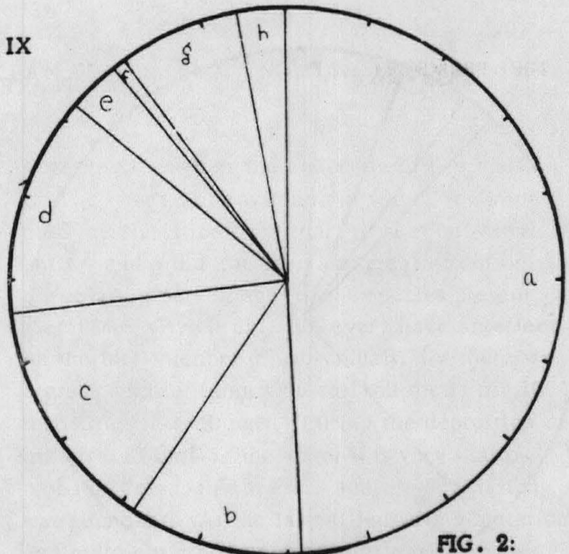

FIG. 2: Coll. 5

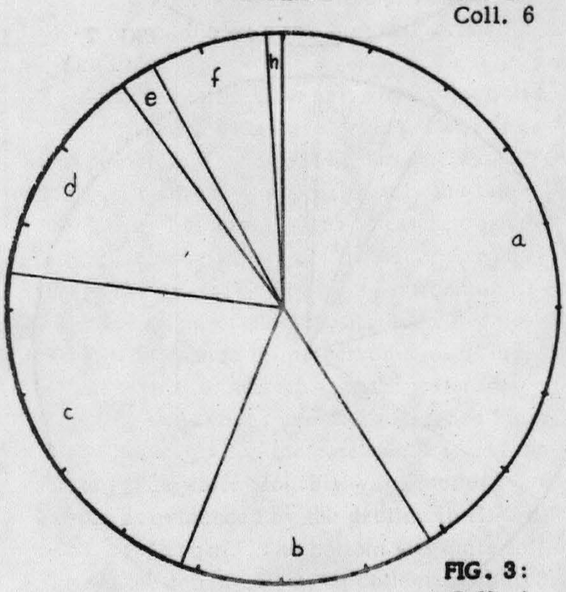

FIG. 3: Coll. 4

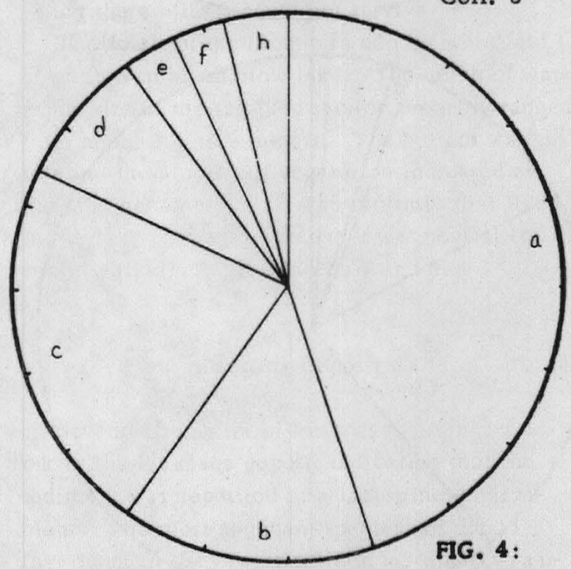

FIG. 4: Coll. 3

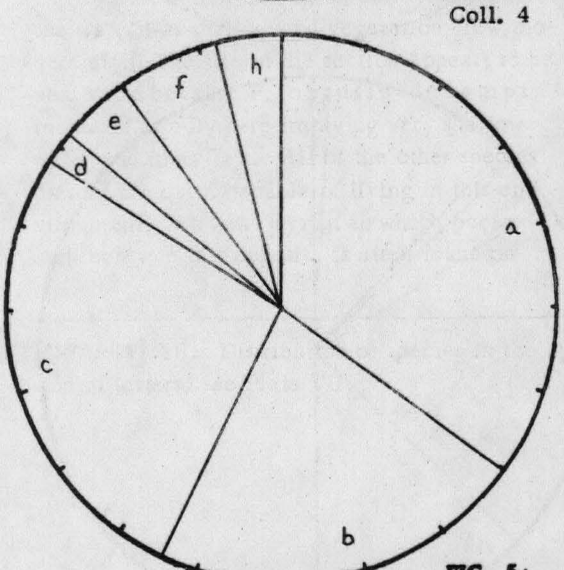

FIG. 5: Coll. 2

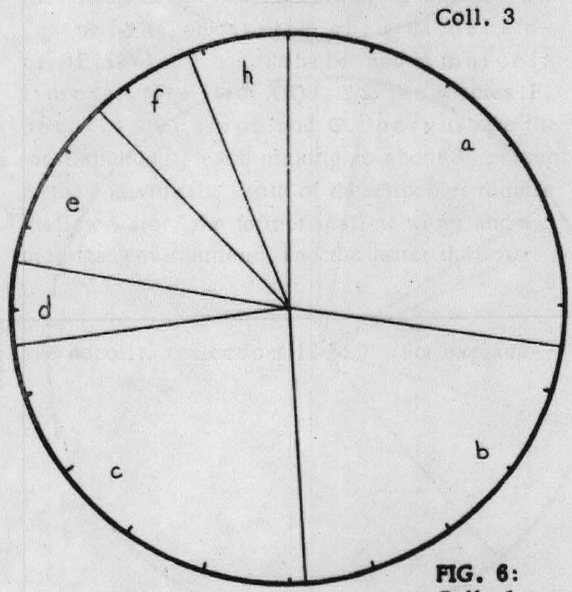

FIG. 6: Coll. 1

water with some vegetation. P. variabile is a species with a wide range of habitats but prefers quiet water in soft sediments, whereas A. limosa likes quiet shallow water with some vegetation.

The species G. parvus remains abundant throughout unit 1, ranging from 25 to 40 percent. (See Plate XII). This persistence in number implies that the environment remained favorable for the species, that is, shallow water with vegetation. It is important to note that Dennis (1928, p. 27) thought that depth of water may be a limiting factor. G. parvus is generally found in shallow water or on vegetation near the top of the water. He also observed that oxygen may be another limiting factor since G. parvus is always found with vegetation that tends to increase the oxygen content of the water.

The amphibious snail F. obrussa decampi is abundant in unit 1, adding further evidence that the water was shallow. The deeper water species V. sincera occurs in the lower part of the unit but probably as an intruder from a deeper part of the lake. In the middle of unit 1, collections 20 to 17, P. variabile decreases suddenly and P. casertanum increases. (See Plate XIII). There was no lithologic change here, nor do any of the other species reflect any other environmental change. It may be that P. casertanum just increased to the point that it took over the position formerly occupied by P. variabile.

In collection 18 there was a decided increase in the number of shells. This change is also shown by some of the gastropods. F. obrussa decampi decreases from 31 percent to 20 percent, A. lustrica increases from 2.6 percent to 10 percent and V. tricarinata increases from 3.4 percent to 10 percent. (See Plate XIII). These seem to mean an environmental change. The most probable one is an increase in depth of water from about 1 meter to 2 to 3 meters. F. obrussa decampi, which prefers shallow water, declines with the depth increase while the 2 species that would prefer slightly deeper water, A. lustrica and V. tricarinata, increase. In collection 17, the percentages return to what they were in collection 19, indicating a return to more shallow water.

There is no indication of a warming trend in unit 1, for H. anceps striatum becomes more abundant upward in the section. The number of species of land snails increases toward the top of unit 1, indicating that they lived near the edge of the lake, most likely in wooded environment, where they could be washed into the water.

The marl of unit 2 contains more plant matter than unit 1, meaning that the vegetation in the lake was becoming more dense. This did not affect the mollusks to any large extent except in collection where V. tricarinata becomes more abundant as the marl grades into peat of unit 3, and F. obrussa decampi becomes much less abundant where the peat prevails.

The extinction of the lake occurred when vegetation took over and the deposit became a bog. Units 4 and 5 represent unfossiliferous organic bog accumulations. A bog exists over much of this site today.

The history of this lake closely resembles that of the lakes already described. It was generally of small size and shallow. The bottom was soft as marl was being deposited through much of the life of the lake. Vegetation was sparse in the early phases, but became more abundant as the lake grew older until it completely dominated and bog conditions prevailed. The living conditions of the species present indicate that the pH of the water was between 7 and 8.

PLATE IX. Distribution of species in the Spur Lake deposit, collections 6 to 1. For explanation of letters, see Plate VII.

Harmony Deposit

The Harmony deposit represents an unusual situation in which only two species make up from 85 to 100 percent of the population throughout. (See Plates XV to XIX). The abundance of fresh water Mollusca indicates that the sediments were deposited in a lacustrine environment. The lowest unit is a calcareous silt in which the shells are rather sparse. The number of shells increases slightly with the change from the silt of unit 1 to the marl of unit 2. The shells continue to increase in number upward in the marl until they are moderately abundant near the top.

The only two common species in the deposit, and the only two that can be considered indigenous throughout, are F. obrussa decampi and G. parvus. The persistence of these species in the section indicates that the environment of the lake remained uniform during its existence. The lake was small in size as shown by the limits of lacustrine sediments. The water was shallow with a moderate amount of vegetation. The lake was probably surrounded by an extensive mud flat for F. obrussa decampi prefers a habitat in shallow water or just out of the water on a mud flat environment. G. parvus also prefers the shallow water environment.

Only one species of clam, P. casertanum, occurred in the lake. This species is adaptable to many habitats and could exist in this shallow water environment. The land snails occur in unit 1 almost exclusively, and were probably washed in with the silt from a surrounding wooded environment. In the marl unit they are rare. Aplexa hypnorum occurs as a rare species and was found only in this deposit. It is generally found in temporary pools and swales and in a swampy environment. It appears that this species was washed into the lake from temporary pools that may have existed around the perimeter of the lake.

Throughout the life of the lake, the environment was most favorable to the two common species, F. obrussa decampi and G. parvus. The relations between these two species do not remain constant. In the silt of unit 1 F. obrussa decampi is by far the more abundant. After the change from silt to marl, there is a definite change in the percentages of these two species. Between collections 22 and 21 the percentage of G. parvus increases from 25 percent to 38 percent and that of F. obrussa decampi drops from 71 to 58 percent. From collections 18 through 13, G. parvus is more abundant. In collections 12, 11, and 10 F. obrussa decampi again becomes abundant. In the top five collections, however, G. parvus is the more abundant by a wide margin. (See Plate XVIII). Significant changes such as those outlined above imply changes in environment. These changes need not be great but only enough to change the habitat in favor of one species or another. In this case only a small change in depth of water might be enough to bring this about. Assuming that the lake had low mud flats, then a rise in water level of only a meter might change the position of the shoreline by 10 feet or more. This change of shoreline will tend to decrease the number of F. obrussa decampi which lives near and on the edge of a lake, and increase the relative number of G. parvus at the site of the section. The shifting of shoreline might account for the change in percentages of the two species involved.

The limits of pH under which F. obrussa decampi can exist are between 7.42 and 7.7

PLATE X. Distribution of species in the Mountain deposit, collections 12 to 7. Each figure represents the percentages of the species present in the collection whose number follows the figure number. Species are represented by letters: a - Valvata tricarinata, b - Gyraulus parvus, c - Pisidium casertanum, d - Fossaria obrussa decampi, e - Amnicola limosa, f - Helisoma anceps striatum, g - Helisoma campanulatum, h - Physa gyrina, i - others.

PLATE X

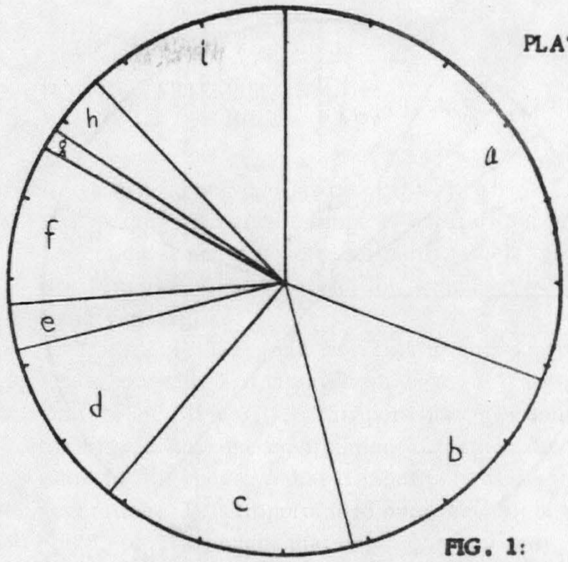

FIG. 1:
Coll. 12

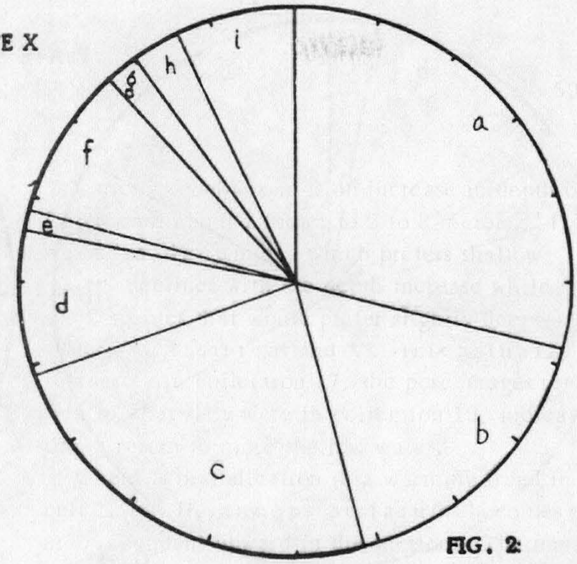

FIG. 2:
Coll. 11

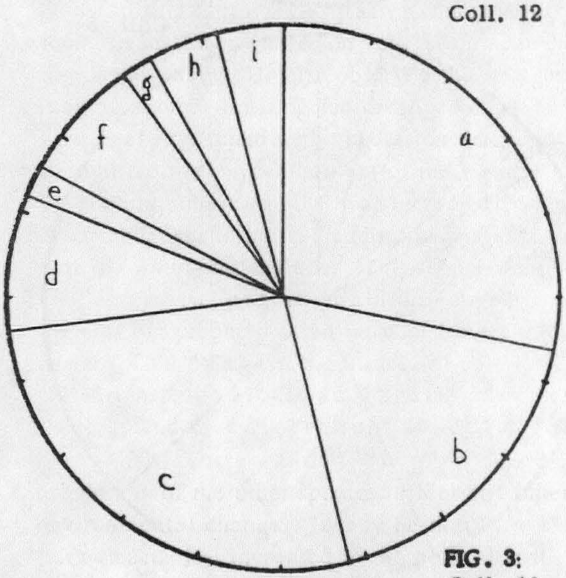

FIG. 3:
Coll. 10

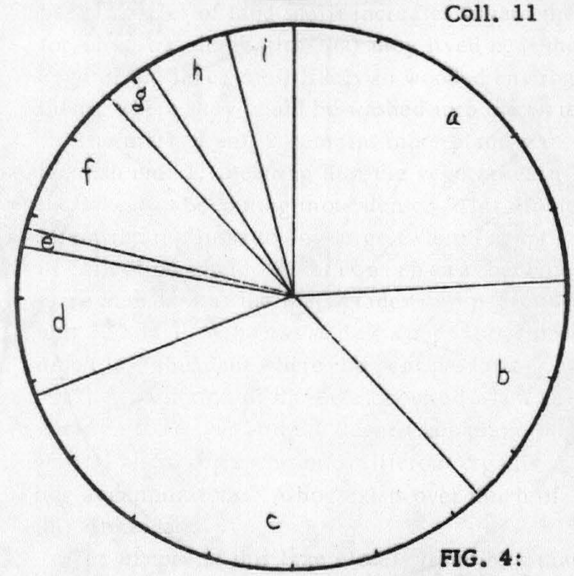

FIG. 4:
Coll. 9

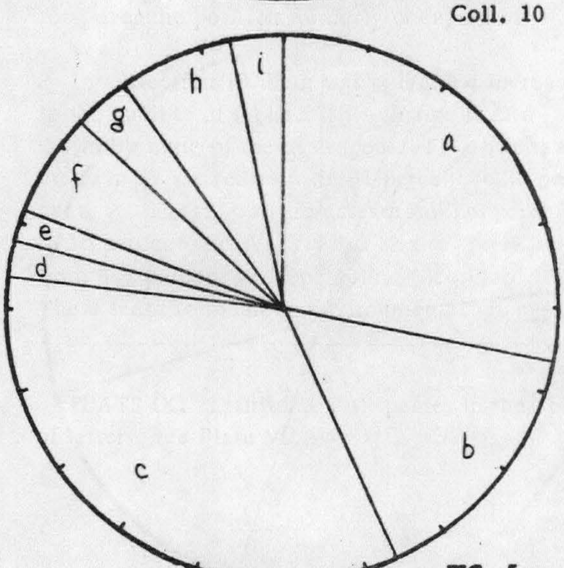

FIG. 5:
Coll. 8

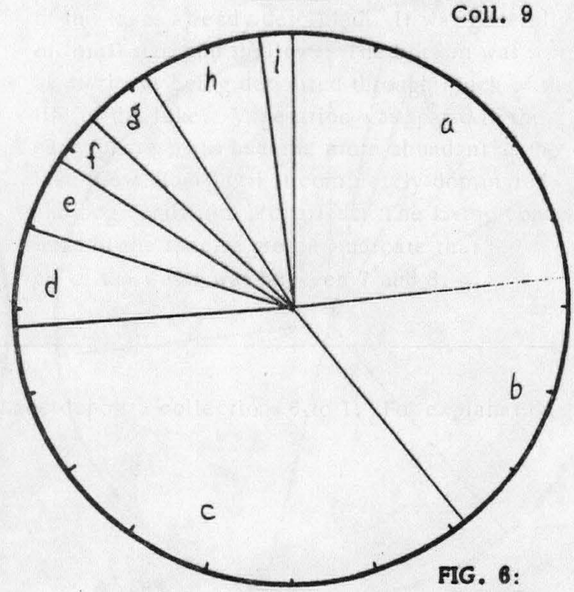

FIG. 6:
Coll. 7

PLATE XI

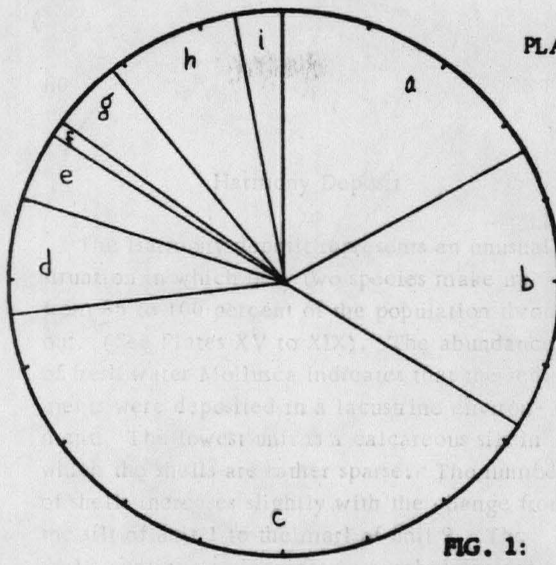

FIG. 1:
Coll. 6

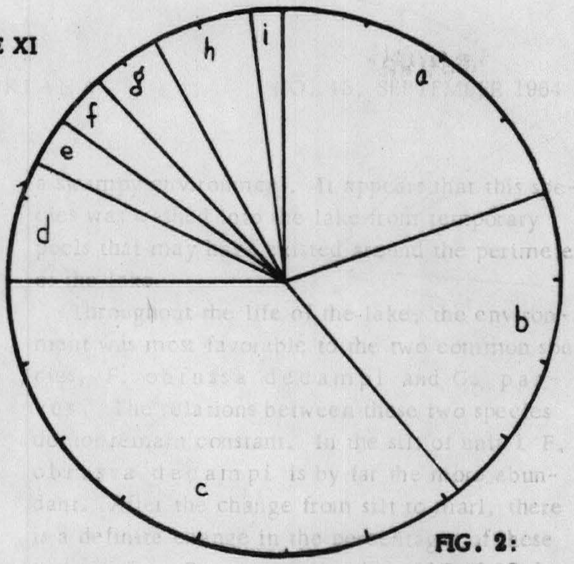

FIG. 2:
Coll. 5

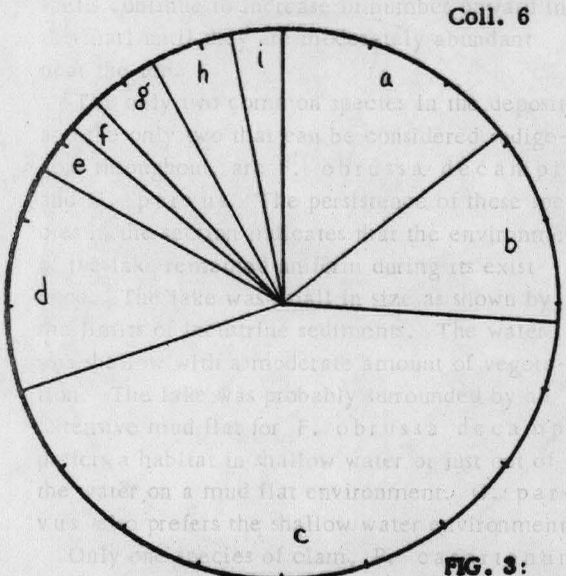

FIG. 3:
Coll. 4

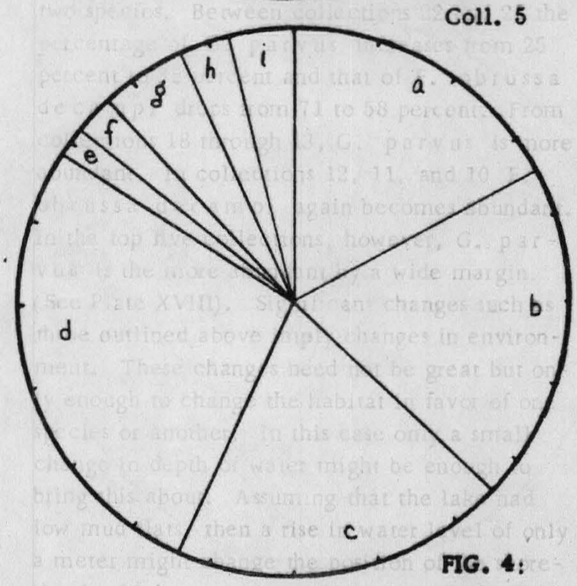

FIG. 4:
Coll. 3

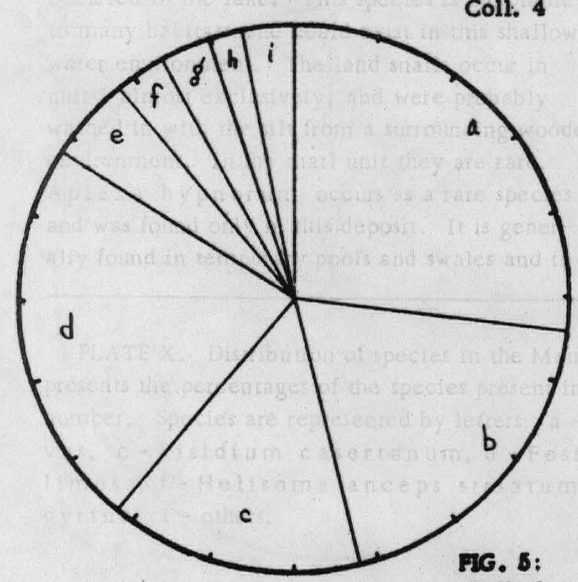

FIG. 5:
Coll. 2

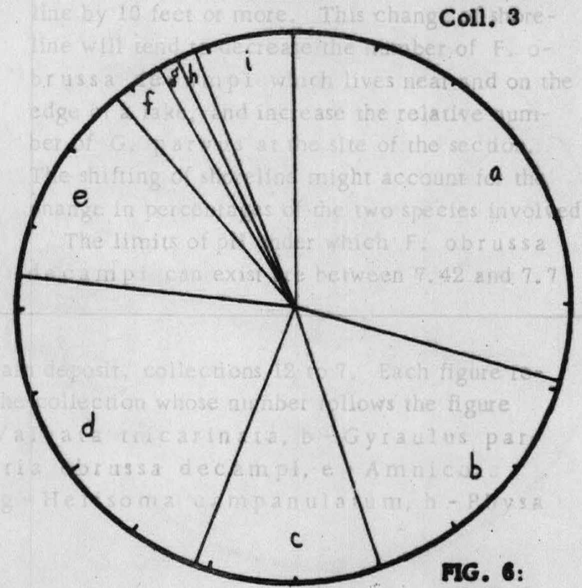

FIG. 6:
Coll. 1

(Morrison, 1932, p. 371). Gyraulus parvus is generally restricted to a pH above 7. Because both of these species occur commonly throughout the life of the lake it can be assumed that the pH of the water was about 7.5.

The highest fossiliferous unit is a dark clay. The number of shells falls off sharply in the transition from the marl to the clay. The clay marks a period when mud, probably derived from the surrounding till, was being deposited in the lake. Swampy conditions prevailed after the clay deposition and these still persist today.

Synopsis of Northeastern Wisconsin Deposits

A comparison of the five northeastern Wisconsin deposits shows that the environment was somewhat similar in each deposit. All of the sites are extinct lakes, except Spur Lake in which water still exists. Each of the lakes had fairly shallow water with sparse to abundant vegetation. The water of the lakes was neutral to slightly alkaline, ranging in pH between 7 and 8. There. There are indications, such as the presence of Helisoma anceps striatum, that the water was colder than at present, during much of the existence of lakes, but may have become warmer later on in their history.

To make the most accurate determination of past environments, it would be desirable to find a living assemblage similar to the fossil assemblage. The data obtained from the living assemblage could then be reliably applied to the fossil assemblage. This is possible for Pleistocene assemblages because most of the species are still living. F. C. Baker (1935) published an account of land and freshwater Mollusca from North Star Lake in northern Minnesota. In his description of the mollusks found in the lake, he cited several examples of assemblages similar to the ones in this paper.

On the west shore of the north bay of North Star Lake Baker (1935, p. 263) found mollusks in 2 to 3 feet of water on a sandy silt and mud bottom. The vegetation was Chara, Potamogeton, Vallisneria, Scirpus, Lemna, Nymphaea, Castalia, and Myriophyllum. The Amnicola and Valvata were obtained by sweeping the Chara, the Sphaerium and Pisidium in the mud bottom, and the Physa and Helisoma in vegetation. His complete list is as follows:

Sphaeriidae:
- Pisidium, 2 species
- Sphaerium sulcatum

Freshwater gill-breathing Gastropods:
- Amnicola limosa
- A. lustrica "decepta"
- Valvata tricarinata

Freshwater lung-breathing Gastropods:
- Gyraulus parvus
- Helisoma anceps striatum
- H. campanulatum
- H. trivolvis "macrostomum"
- Lymnaea stagnalis jugularis
- Physa gyrina

No data on abundance were given.

This assemblage, with a few exceptions, is very similar to 4 of the northeastern Wisconsin deposits, White Lake, Spur Lake, Mountain, and Waupaca. The exceptions are the absence of Fossaria and the presence of Helisoma trivolvis "macrostomum" in the living assemblage. It is interesting to note that the habitat of the living assemblage from North Star Lake is similar to the general paleoecology of the 4 extinct lakes as determined from fossil data.

PLATE XI. Distribution of species in the Mountain deposit, collections 6 to 1. For explanation of letters, see Plate X.

From the small Little North Star Lake, Baker (1935, p. 266) records an assemblage that occurred near the south end. Here the water was shallow, about 3 feet deep, and the bottom was muck. The vegetation present was Typha, Scirpus, Potamogeton, Nymphaea, Castalia, Lemna, and Chara. The list of species is as follows:

Sphaeriidae:
- Pisidium (2 species)
- Sphaerium securis

Freshwater gill-breathing Gastropods:
- Amnicola limosa
- A. lustrica "decepta"
- Valvata tricarinata

Freshwater lung-breathing Gastropods:
- Fossaria obrussa decampi
- Gyraulus deflectus obliquus
- G. parvus
- Helisoma anceps striatum
- H. trivolvis "macrostomum"
- H. campanulatum
- Physa gyrina
- Promenetus exacuous

Land Gastropods:
- Oxyloma retusa

No abundance data were given.

This assemblage is similar to all 5 assemblages of this report. It would be safe to assume that the 5 fossil assemblages probably lived in an environment very much like the two described above. It might also be safe to assume that the climate in northeastern Wisconsin when the 5 lakes were in existence is similar to that of northern Minnesota today.

Tuthill et al. (1964, pp. 350-361) discuss a comparison of a Late Wisconsin fossil molluscan fauna from the Missouri Coteau of North Dakota with a living molluscan fauna from Long Lake in north central Minnesota. Their conclusions are that since the two faunas are so similar, the climate of the North Dakota site was like that of the Minnesota lake today. The important point, however, is that they state "The geology of the Coteau indicates the presence of a buried band of stagnant glacier ice a few hundred feet thick (30 miles wide at many places) concurrent with the zenith of the molluscan inhabitation." This suggests that the mollusks were able to exist despite the near proximity of glacier ice because the ice was heavily covered with drift.

This same type of situation could have occurred in northeastern Wisconsin during the Valders retreat. It means that the mollusks could survive a short distance from the glacier front during advance and then repopulate the area immediately after glacial retreat even though stagnant ice remained. It is possible that one or more of the 4 deposits, White Lake, Spur Lake, Mountain, or Waupaca could have been in existence during the Valders glaciation.

An examination of Tables 3 to 7 will show which species first populated the 5 deposits. Each is a relatively small mollusk which probably indicates ease of dispersal. Only 30 species occur in the 5 deposits. This is an incomplete population for such a large area. Over 100,000 shells were examined which should present a broad picture of the molluscan fauna. Obviously many species are absent which today live in northeastern Wisconsin. A total of 307 species of fresh water Mollusca have been recorded for the state (Roy, 1963). Many of these species would not be expected in northeastern Wisconsin, nor in the particular ecologic conditions represented by the 5 deposits. There are, however, notable absences.

The Naiades or large fresh water mussels are

PLATE XII. Distribution of species in the Waupaca deposit, collections 26 to 21. Each figure represents the percentages for the species present in the collection whose number follows the figure number. Species are represented by letters: a - Gyraulus parvus, b - Fossaria obrussa decampi, c - Amnicola limosa, d - Valvata tricarinata, e - Pisidium casertanum, f - Pisidium variabile, g - Helisoma anceps striatum, h - Physa gyrina, i - Amnicola lustrica, j - others.

PLATE XII

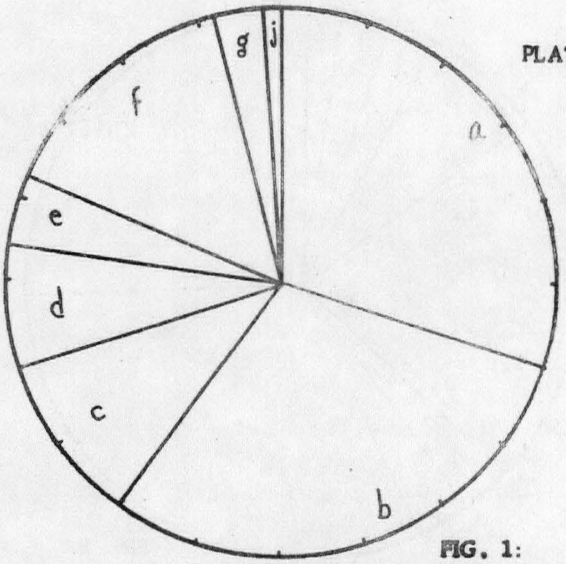

FIG. 1:
Coll. 26

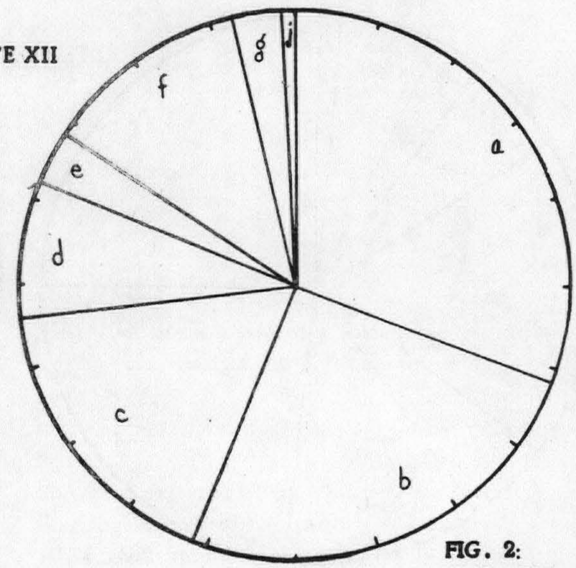

FIG. 2:
Coll. 25

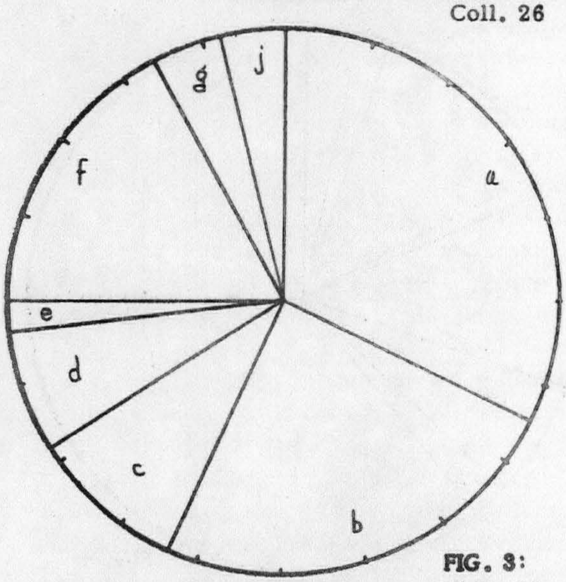

FIG. 3:
Coll. 24

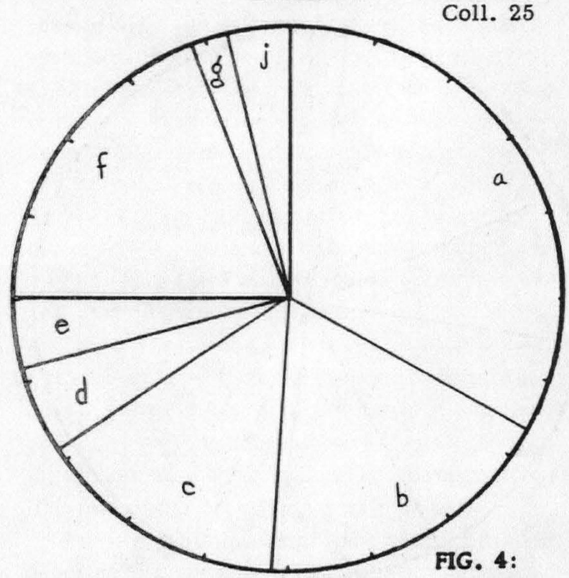

FIG. 4:
Coll. 23

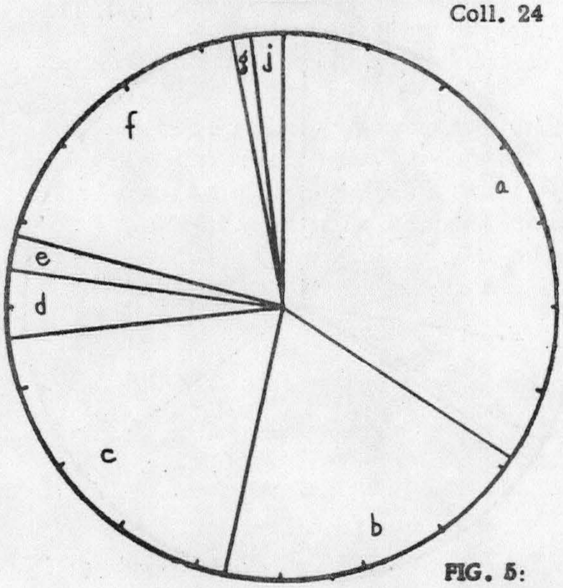

FIG. 5:
Coll. 22

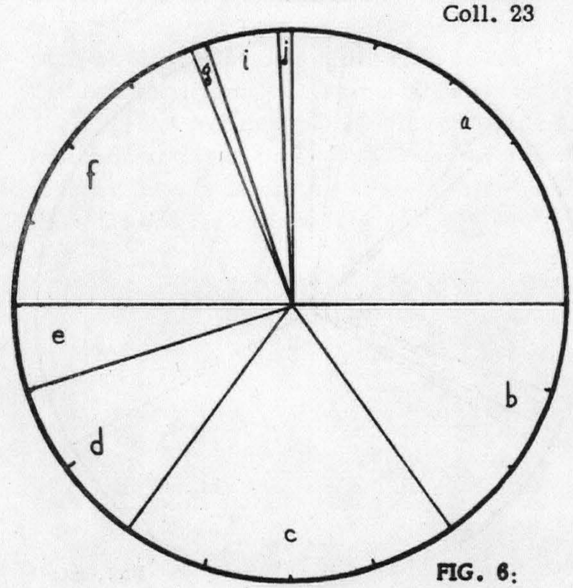

FIG. 6:
Coll. 21

PLATE XIII

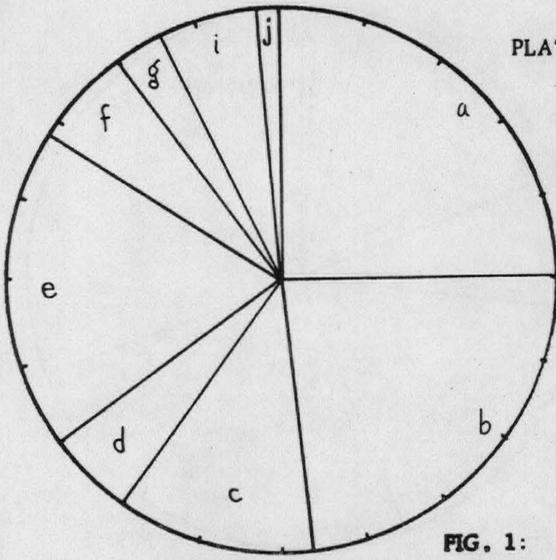

FIG. 1:
Coll. 20

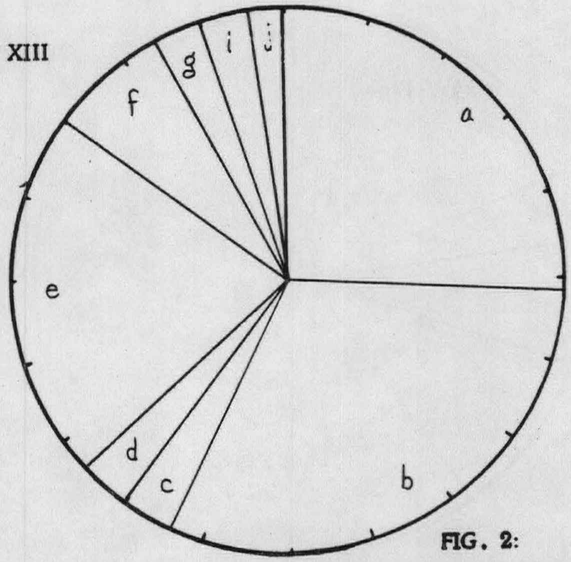

FIG. 2:
Coll. 19

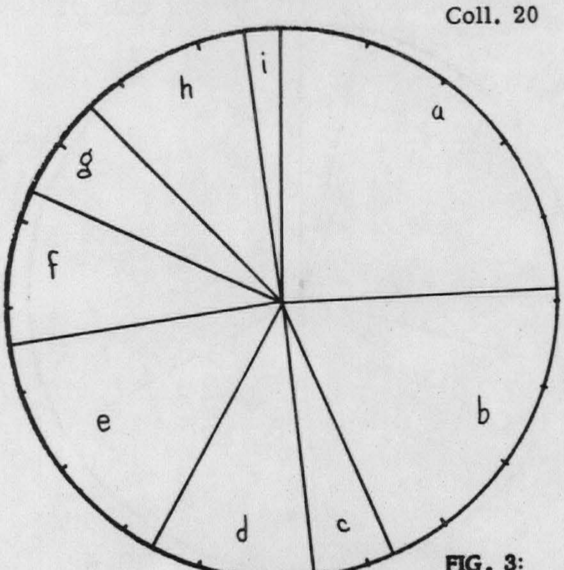

FIG. 3:
Coll. 18

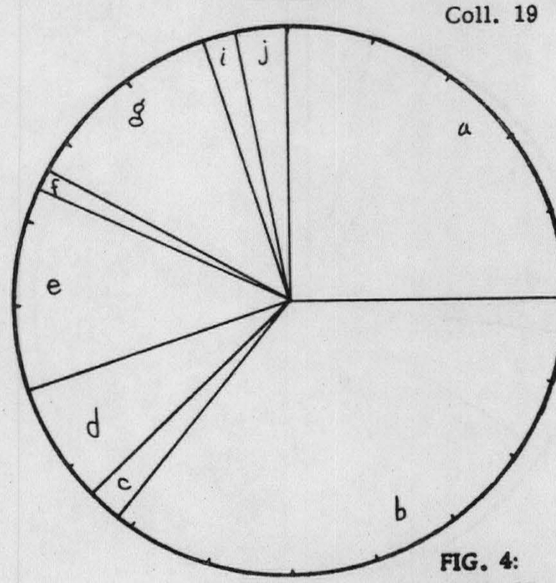

FIG. 4:
Coll. 17

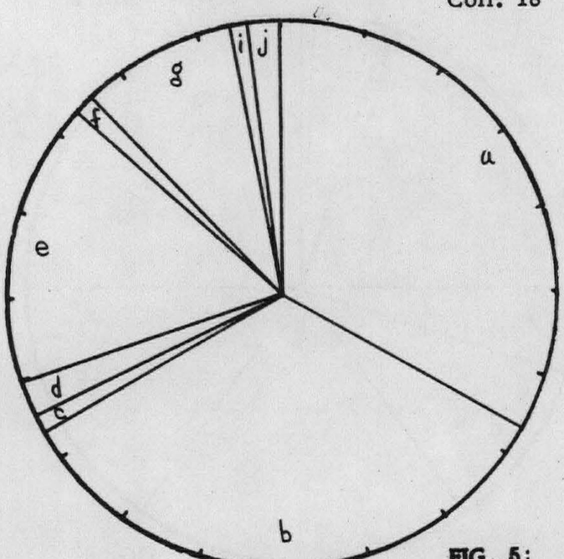

FIG. 5:
Coll. 16

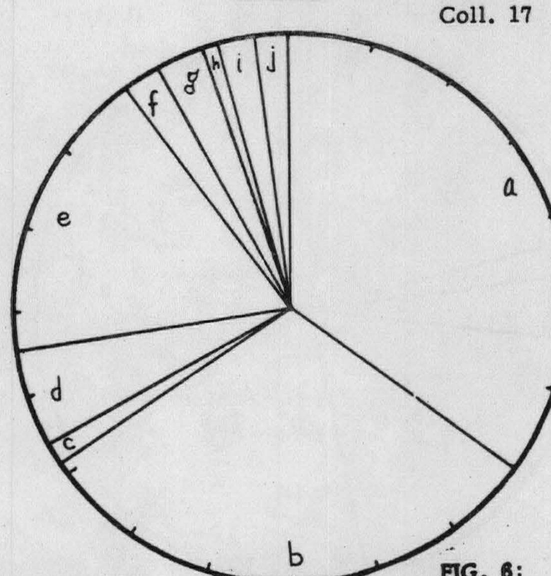

FIG. 6:
Coll. 15

the most obviously missing group. This could be accounted for in a number of ways. (a) The environment of the deposits was not suitable. (b) They were in the deposit but either were not found or were not preserved. (c) The deposits were isolated and the means of dispersal of the Naiades did not enable them to reach the lakes. Of the three, a and b can probably be ruled out because the ecology was suitable and at least fragmentary remains should have been found if this group were present. The third, c, is probably most likely because the former lakes may have been isolated from waterways of dispersal, which could prevent fish, which are necessary as parasitic hosts of the Naiades, from reaching them.

Other notable mollusks which are absent but should be present are Campeloma, Bulimnea, Acella, and the species Helisoma trivolvis. All of these are probably late arrivals in this area. As a general statement it might be said that the species represented in the 5 deposits are those species which have a rapid rate of dispersal and the ability to withstand the cooler climate of the Late Pleistocene.

AGE AND CORRELATION

Exact determination of the ages of the 5 northeastern Wisconsin deposits is difficult. None of the species occurring in these deposits will serve as an index fossil for the Late Wisconsin to Recent. The only fairly accurate age determination that can be made is by the radiocarbon method. This was not done in this study because of lack of funds.

The ages can be determined, however, on the basis of relation to other sediments of known age. The deposits all rest on glacial drift of either Cary or Valders age. This would mean that the deposits are either post-Cary or post-Valders in age. The White Lake deposit rests on definite Cary outwash. The sites of the Spur Lake and Mountain deposits are probably on Cary outwash but it is possible that the outwash is Valders. The Waupaca deposit is located on a pitted outwash plain of either Cary or Valders age. Lake sediments of the Harmony deposit are located on Valders ground moraine. This would then limit the maximum age of the deposits to a time just after the deposition of the youngest sediment on which they rest.

The length of time between the deposition of the drift and the formation of the lake and arrival of the mollusks is not known. For 4 of the deposits the contact between the underlying drift and the lake sediment was observed. An 8-inch unit of unfossiliferous peat separated the Cary outwash and the first fossiliferous unit in the White Lake deposit. This would indicate that there was a considerable length of time before the mollusks invaded the site. The area of this deposit was the first free of ice in Late Wisconsin time and it was probably not until some time later that the lake was formed. The ice stood at the Mountain moraine just west of this site for a considerable length of time, so it is probable that the lake had formed and the mollusks lived there before the retreat of the Cary ice from northeastern Wisconsin.

The contact between the drift and the lake marl of both the Mountain and Waupaca deposits is quite sharp, indicating that the lake was in existence immediately or soon after the last of the drift was deposited. Mollusks occur in these lowest marls. The contact between the

PLATE XIII. Distribution of species in the Waupaca deposit, collections 20 to 15. For explanation of letters, see Plate XII.

Valders ground moraine and the lowest lake sediments of the Harmony deposit is also sharp. It would thus appear that these lakes came into existence soon after the ice retreated and that the mollusks inhabited them almost immediately.

All of the deposits except Spur Lake are extinct and are covered by bog or swamp deposits. It might be assumed, from the amount of peat and muck covering the former lake sediments, that the lakes have been extinct for a considerable length of time, probably a few thousand years. The age of the 5 deposits in northeastern Wisconsin, in the light of present information, is considered to be Late Wisconsin.

There is no direct means of correlation among the 5 deposits of northeastern Wisconsin. It is very probable, though, that all 5 lakes existed together during part if not all of their lives. The presence of fairly similar faunas in the lakes would imply that they were probably populated at about the same time. The species Gyraulus parvus and Fossaria obrussa decampi occur in each lake in the lowest fossiliferous collection. The species of Amnicola are common in 4 of the lakes. The presence of these species in the lowest units indicates they entered the lakes as soon as they became habitable.

The general distribution of species shows that the dispersal throughout the area during the time when the lakes existed was nearly complete. Eight species occur in all 5 lakes, 8 in 4 of the lakes, and 3 others in 3 of the lakes. (See Table 1). As important as the species present are the ones that are absent. The most notable ones are the Naiad group, the genera Campeloma, Bulimnea, Acella, a number of species of Stagnicola, and Helisoma trivolvis. All of these are present in northeastern Wisconsin today. It is apparent that these species came into northeastern Wisconsin after the extinction of the 5 lakes.

On the basis of the presence of some species and on the absence of the other species, it is assumed that all five lakes existed during the same general interval of the Late Wisconsin.

CONCLUSIONS

The five extinct lakes studied in northeastern Wisconsin yielded a total of 30 species of nonmarine Mollusca. The maximum number of species occurring in any one lake was 21. (See Table 1). The distribution of the most common species was quite uniform; 8 species occurred in all 5 lakes and 8 other species occurred in 4 of the lakes.

The paleoecology of each deposit was reconstructed from data obtained by a quantitative and qualitative study of the mollusks. The general ecologic conditions of each deposit were similar. The water was fairly shallow from 0.5 to 3 meters in depth. The bottom was soft and vegetation grew in varying amounts, but was in general from moderate to dense. The water was neutral to slightly alkaline ranging in pH from 7 to 8. Although this was the general character of the lakes throughout their existence, minor changes in the molluscan population reflected small changes that took place in the environment.

The lithology of the deposits varied from marl to peat. The difference in lithology had a noticeable effect on the number of individuals. In

PLATE XIV. Distribution of species in the Waupaca deposit, collections 14 to 9. For explanation of letters, see Plate XII.

PLATE XIV

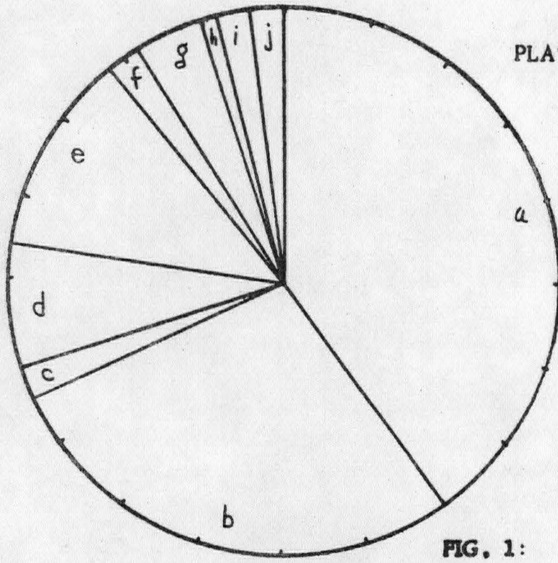

FIG. 1:
Coll. 14

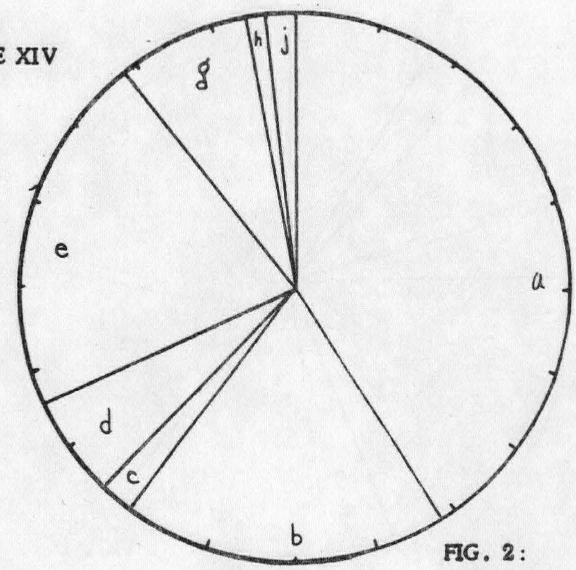

FIG. 2:
Coll. 13

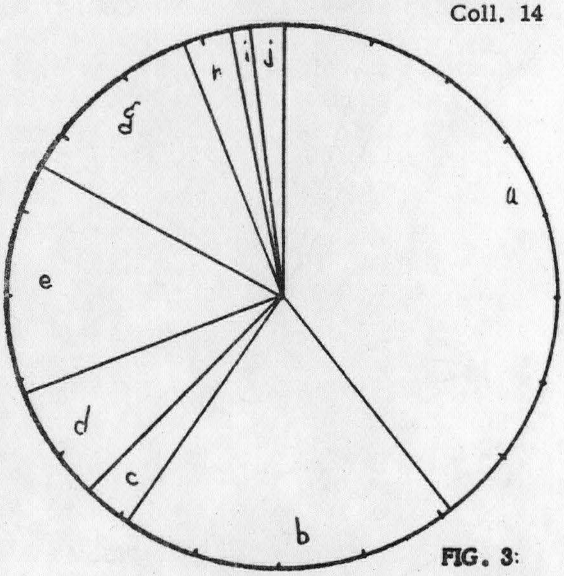

FIG. 3:
Coll. 12

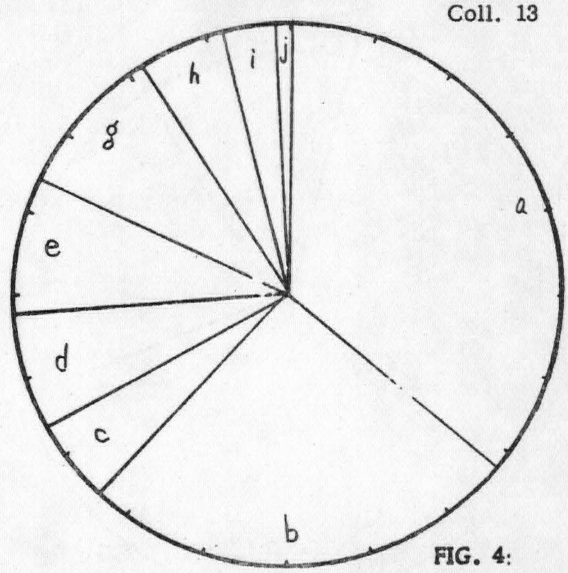

FIG. 4:
Coll. 11

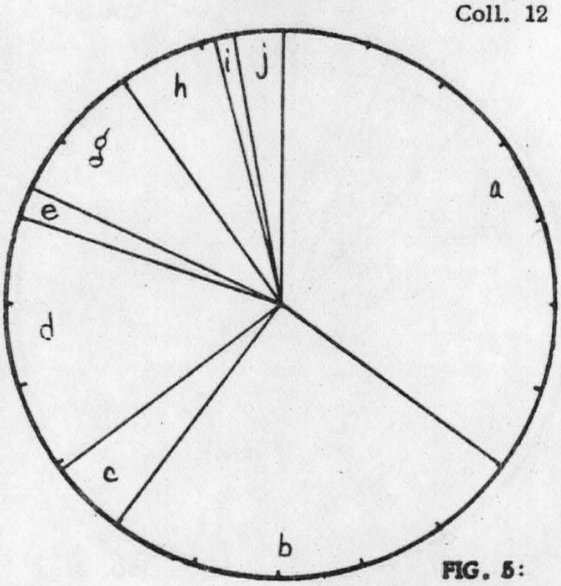

FIG. 5:
Coll. 10

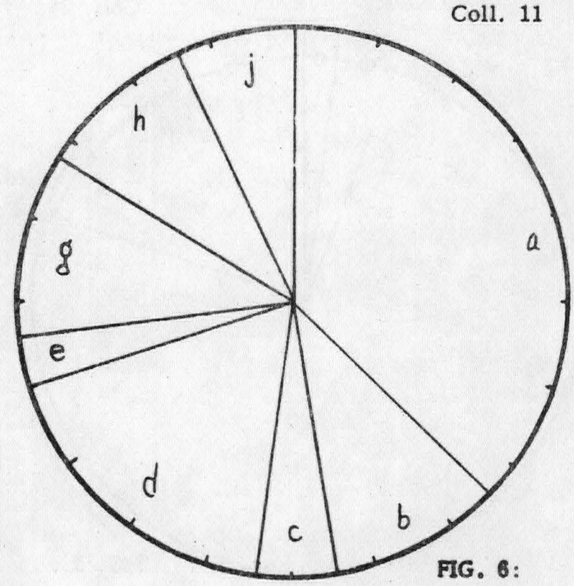

FIG. 6:
Coll. 9

PLATE XV

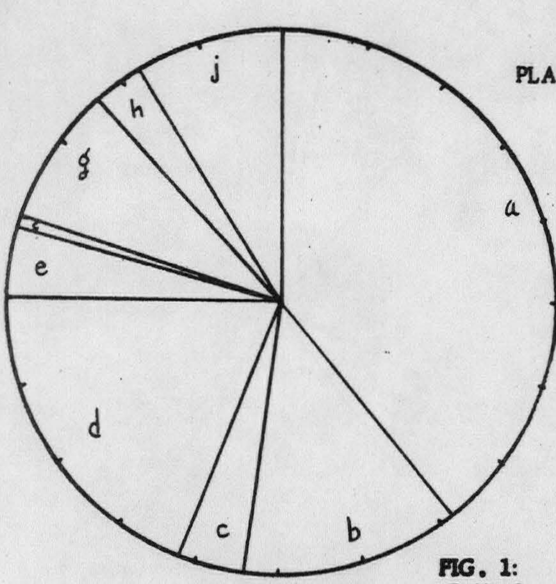

FIG. 1:
Coll. 8

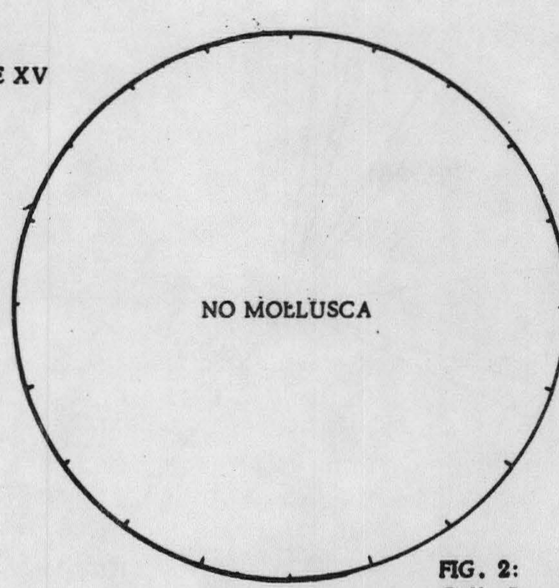

FIG. 2:
Coll. 7

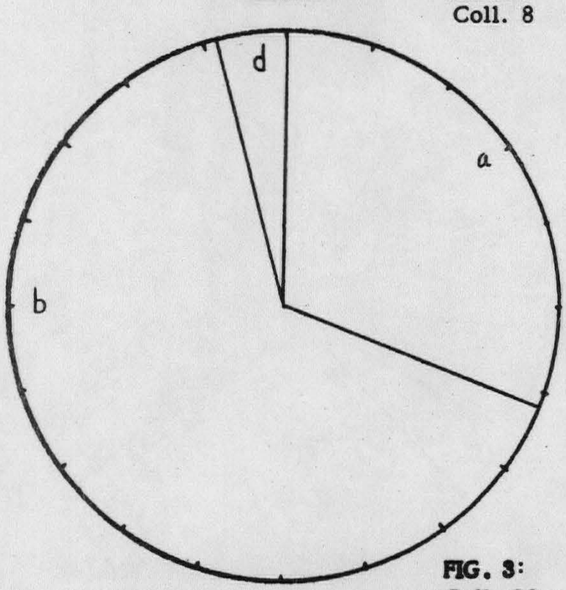

FIG. 3:
Coll. 29

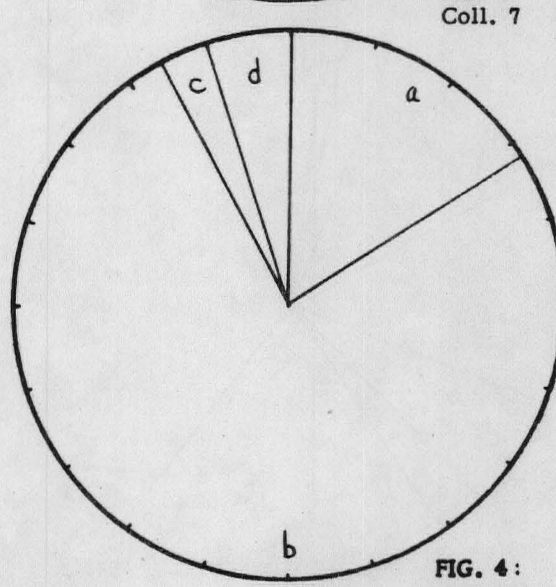

FIG. 4:
Coll. 28

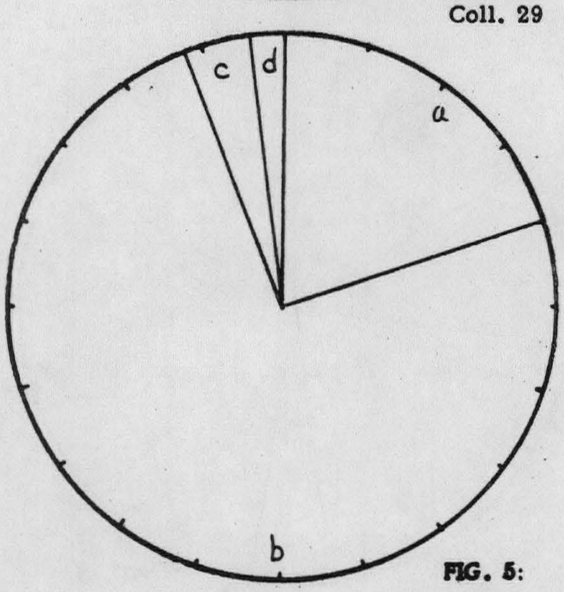

FIG. 5:
Coll. 27

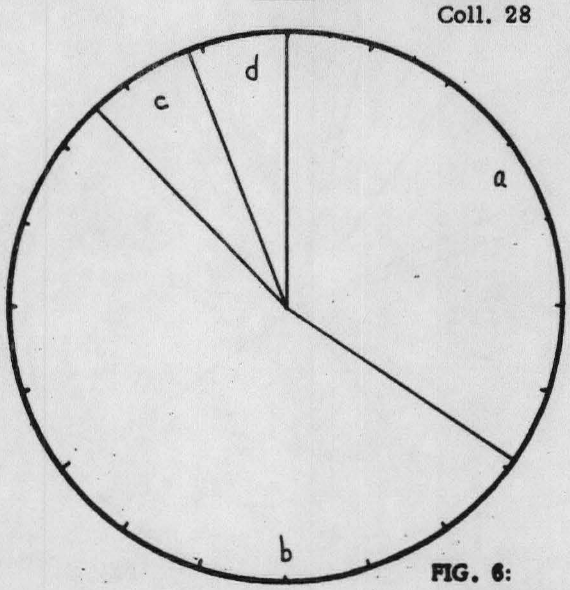

FIG. 6:
Coll. 26

the marl the number of shells was much higher than in the peat indicating that the Mollusca preferred a habitat in which marl was being deposited, to a habitat very dense in vegetation. The presence of peat also indicated that the water in the lake was very shallow. Dense vegetation seemed to have little effect on the relative percentages of the species.

Although a species may get into a given lake or pond there is no guarantee that it will persist. There is evidence of this in some of the deposits. In the Harmony deposit V. tricarinata and H. anceps striatum occur in the lower part of the section but do not occur in the upper part. Sphaerium lacustre, S. sulcatum, and V. sincera are present for a short time in the Waupaca deposit. These intruders were brought into the lake from elsewhere or from another environment in the lake and could not survive for any long period of time under the given conditions. The species that do not occur in the lower units but do occur farther up in the section and persist through the remainder of the section are probably late arrivals into the lake.

The quantitative study of the individuals at small intervals reflected numerous significant changes in the percentages of the species. These changes, while not connected with lithology, are important in terms of depth of water and distance to shoreline. The importance of this was brought out in the Harmony deposit where the percentages of G. parvus and F. obrussa decampi changed throughout the section, probably indicating an increase in water depth and a shifting of the edge of the lake away from the site of the section. Without quantitative information the fossil fauna has little significance for use in determining former environment. Although 21 species do occur in two deposits, only a few of these are native to a given environment. These occur most abundantly and are the ones on which the greatest significance should be placed when reconstructing an environment.

There is evidence that many of the species that occurred in the lakes inhabited them almost immediately after they were formed. Evidence from the stratigraphy of the deposits indicates that the lakes formed very soon after the last glacial deposits were laid down. From the two above statements it can be concluded that the mollusks migrated into northeastern Wisconsin shortly after the retreat of the Late Wisconsin ice. It should be noted, though, that the molluscan fauna that lived in the 5 lakes was not the total fauna that lives in northeastern Wisconsin today.

The group of mollusks that first arrived in the area after deglaciation was in general characterized by small size. Small size probably indicates ease of dispersal. Most of these species can now live in areas farther north and are able to withstand the cooler climate. The Mollusca of importance that did not occur in any of the deposits but that do now live in northeastern Wisconsin are Lymnaea stagnalis, Bulimnea megasoma, Acella haldemani, and Helisoma trivolvis. Lymnaea stagnalis did occur rarely in the White Lake deposit but can not be considered native. These species represent some of the larger gastropods which were probably much slower in rate of dispersal. They entered northeastern Wisconsin during a second wave of migration, after the extinction of the five lakes.

Two of these species are important in terms of migration. Acella haldemani and Lymnaea stagnalis jugularis live in

PLATE XV. Figures 1 and 2, Distribution of species in the Waupaca deposit, collections 8 and 7. For explanation of letters, see Plate XII. Figures 3 to 6, Distribution of species in the Harmony deposit, collections 29 to 26. Each figure represents the percentages for the species present in the collection whose number follows the figure number. Species are represented by letters: a - Gyraulus parvus, b - Fossaria obrussa decampi, c - Pisidium casertanum, d, - others.

northeastern Wisconsin today. They have not been recorded for the Late Wisconsin in northeastern Wisconsin. They have, therefore, apparently migrated there in recent times.

These same two species, however, have been recorded for the Late Wisconsin in Ohio. Zimmerman (1958) and Aukeman (1960) recorded both A. haldemani and L. stagnalis jugularis for the Late Wisconsin. Cornejo (1959) and Sheatsley (1960) recorded A. haldemani. These two species are not known to be living in Ohio now.

The two species show a definite migration to the north since the end of the Wisconsin age. It appears that the cause of their migration was the changing climate of the Late Pleistocene. They inhabited Ohio during a time when the climate was suitable and the climate farther north was still too rigorous. As the environment became more suitable to the north after the final retreat of the glaciers these species migrated northward. Ohio, by that time, had probably become too warm for their existence. Ohio during the last part of the Late Wisconsin was probably similar in climate to northeastern Wisconsin today.

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PLATE XVI. Distribution of species in the Harmony deposit, collections 25 to 20. For explanation of letters, see Plate XV.

PLATE XVI

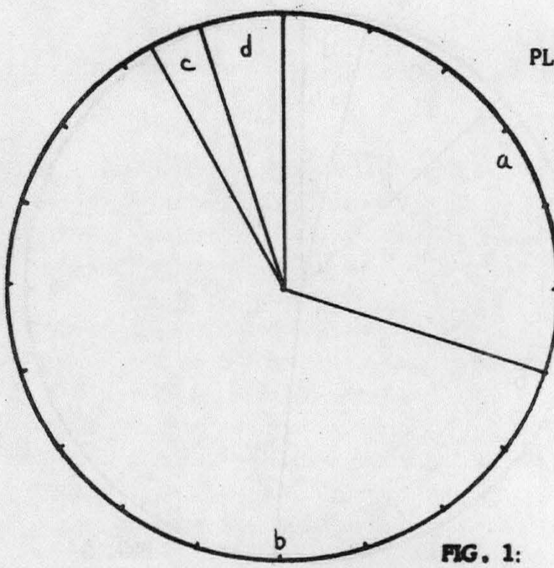

FIG. 1:
Coll. 25

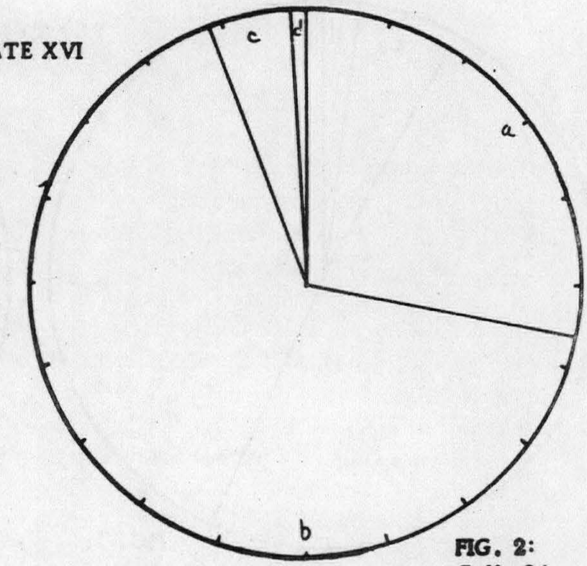

FIG. 2:
Coll. 24

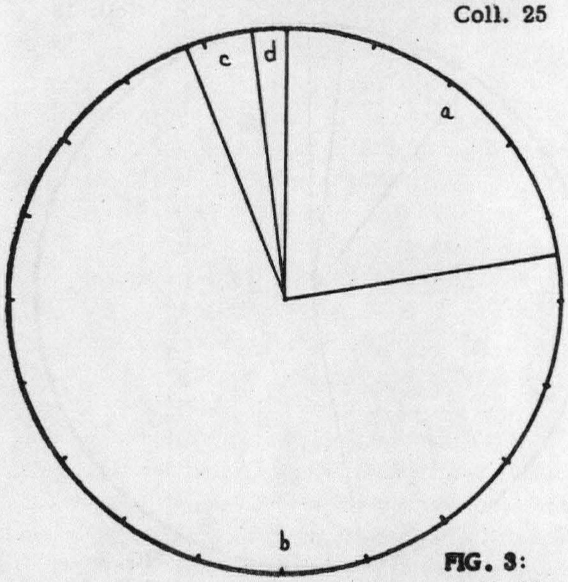

FIG. 3:
Coll. 23

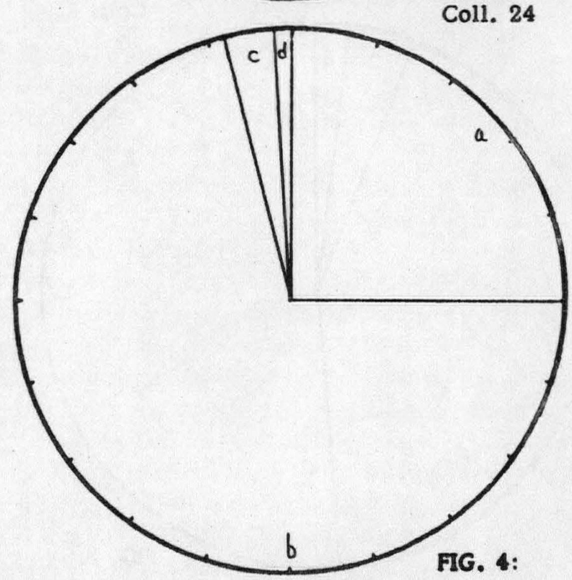

FIG. 4:
Coll. 22

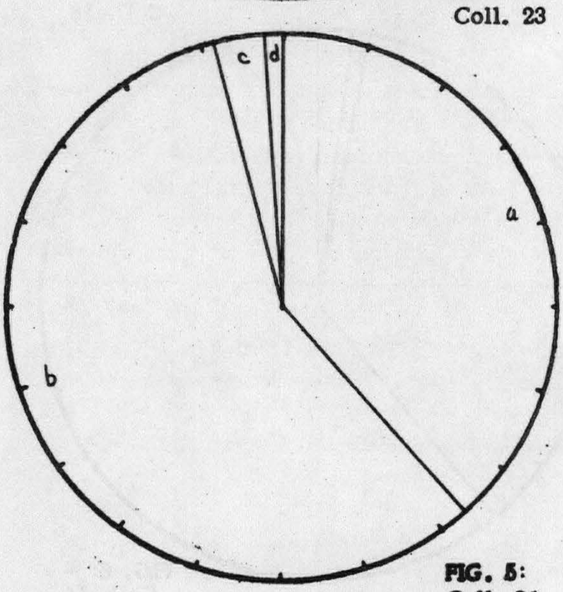

FIG. 5:
Coll. 21

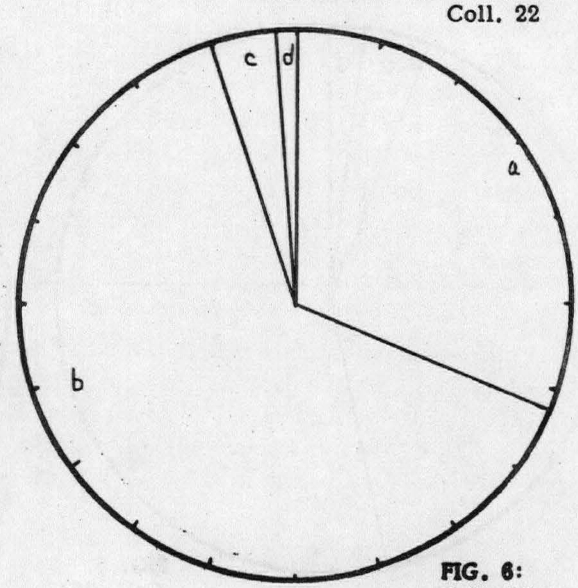

FIG. 6:
Coll. 20

PLATE XVII

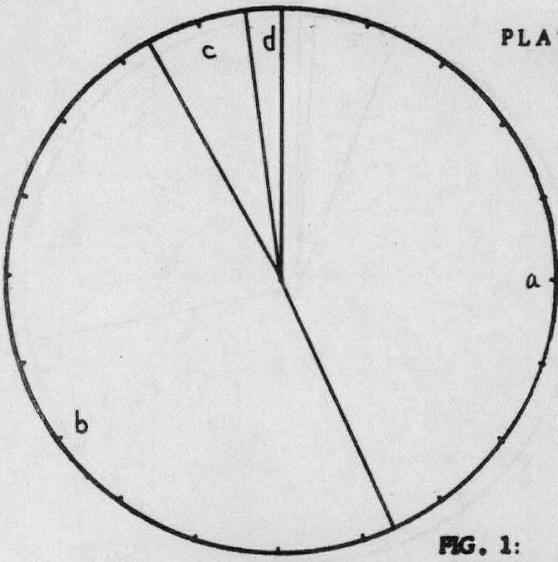

FIG. 1:
Coll. 19

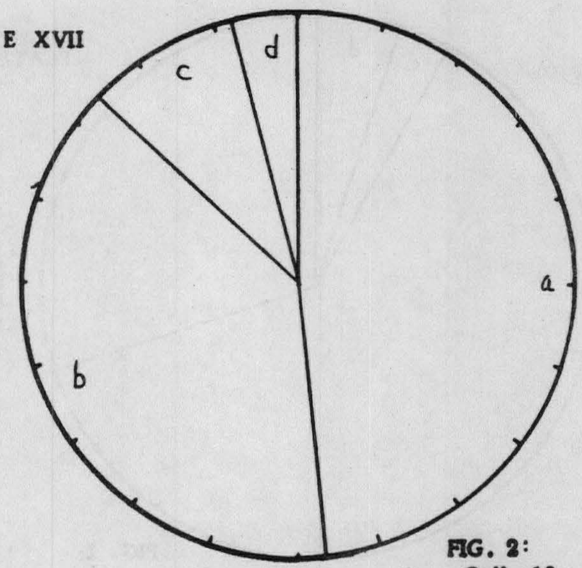

FIG. 2:
Coll. 18

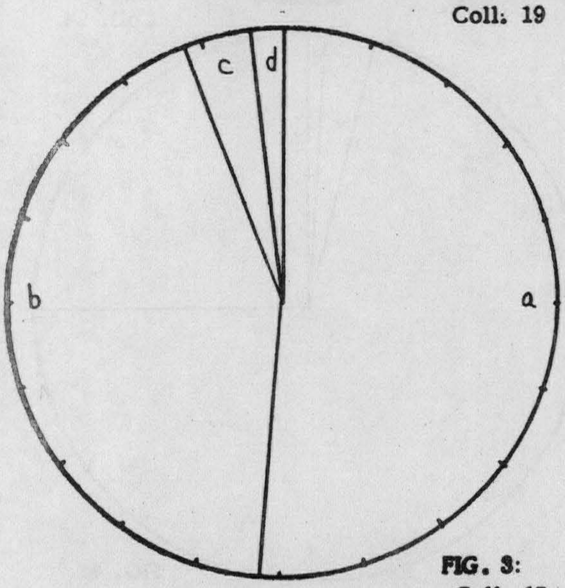

FIG. 3:
Coll. 17

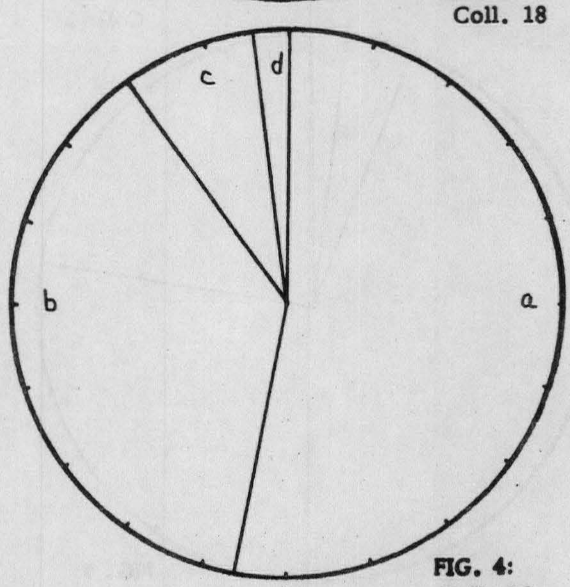

FIG. 4:
Coll. 16

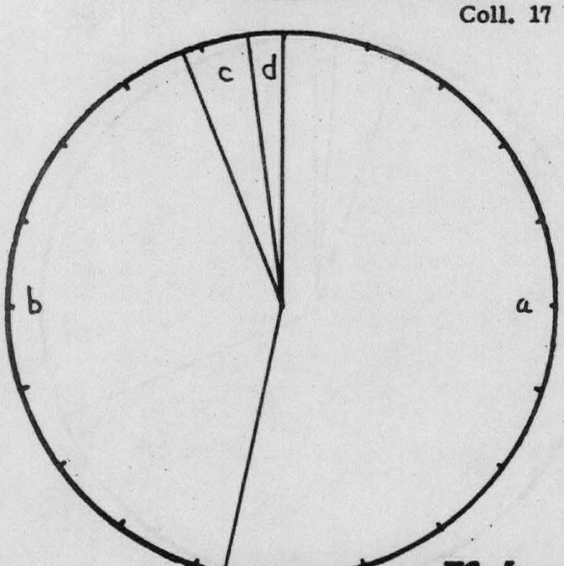

FIG. 5:
Coll. 15

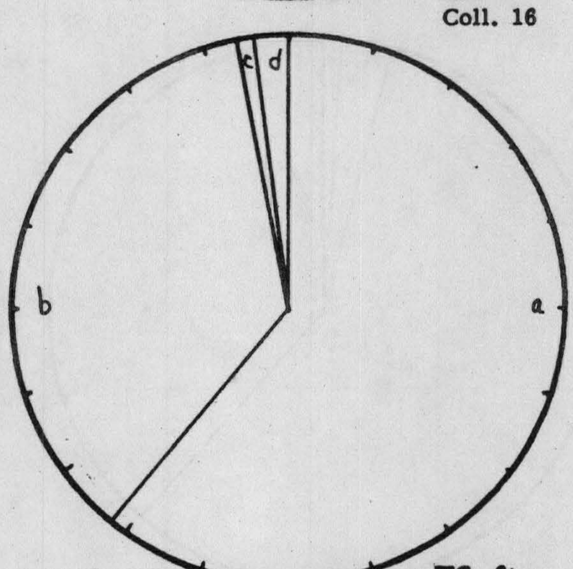

FIG. 6:
Coll. 14

12, pp. 51-96, No. 13, pp. 97-127, No. 14, pp. 129-148.

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PLATE XVII. (Opposite page) Distribution of species in the Harmony deposit, collections 19 to 14. For explanation of letters, see Plate XV.

PLATE XVIII. (page 76) Distribution of species in the Harmony deposit, collections 13 to 8. For explanation of letters, see Plate XV.

PLATE XIX. (page 77) Distribution of species in the Harmony deposit, collections 7 to 2. For explanation of letters, see Plate XV.

PLATE XVIII

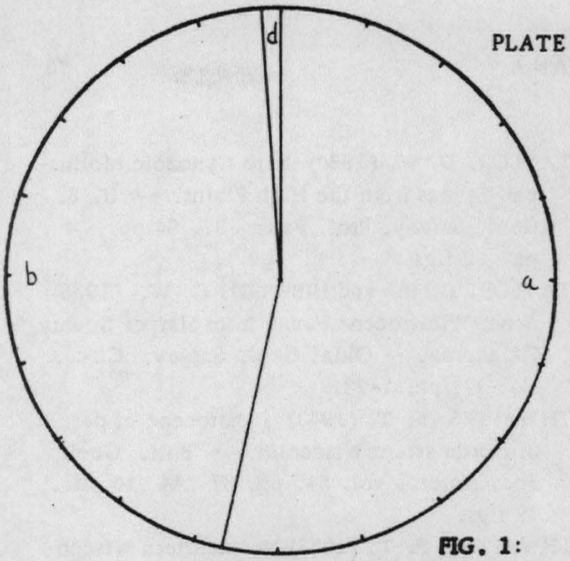


FIG. 1:
Coll. 13

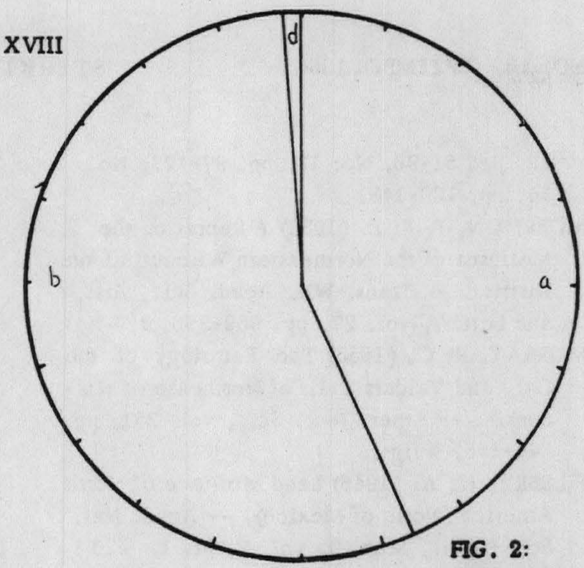


FIG. 2:
Coll. 12

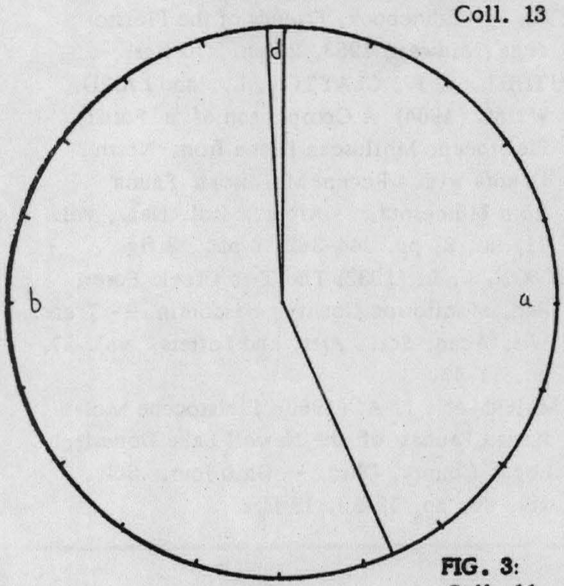


FIG. 3:
Coll. 11

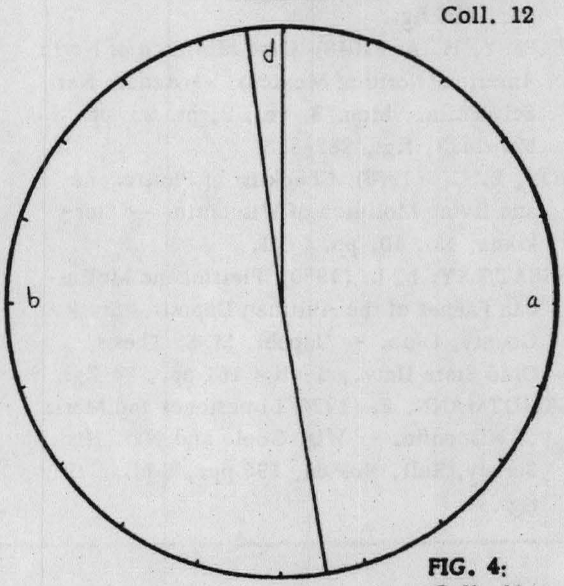


FIG. 4:
Coll. 10

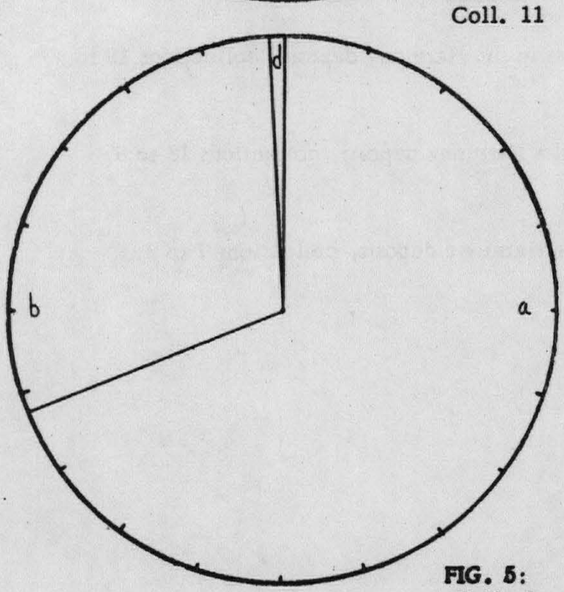


FIG. 5:
Coll. 9

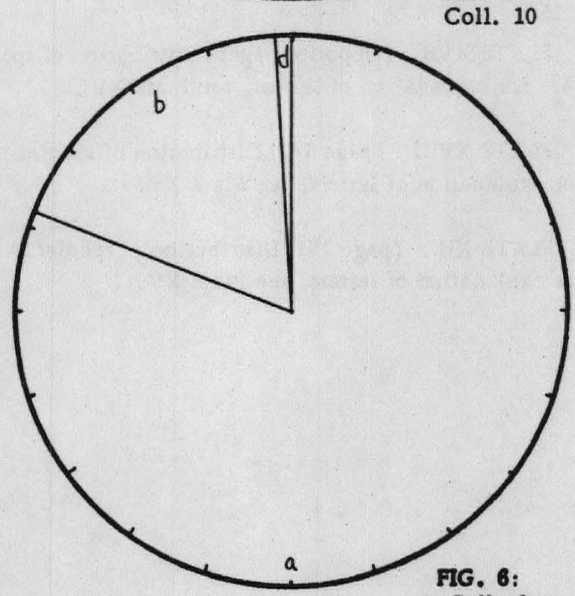


FIG. 6:
Coll. 8

PLATE XIX

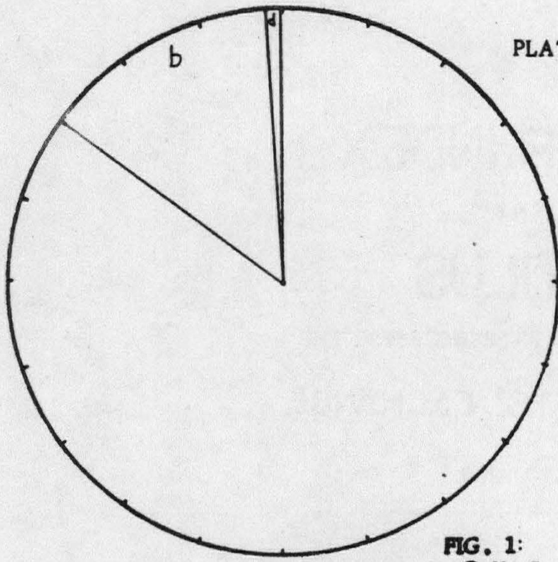


FIG. 1:
Coll. 7

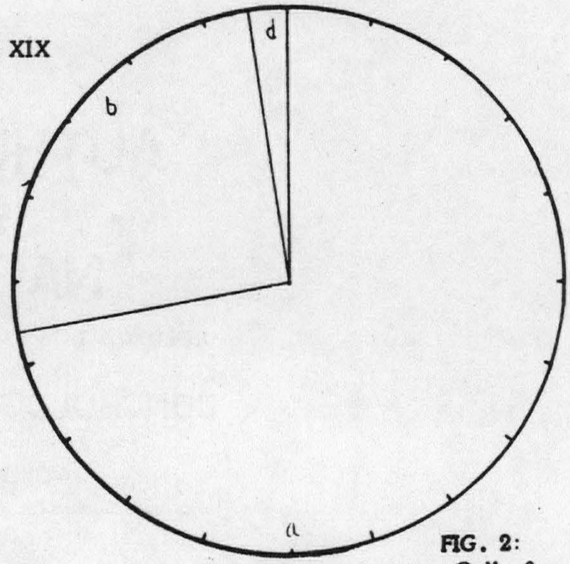
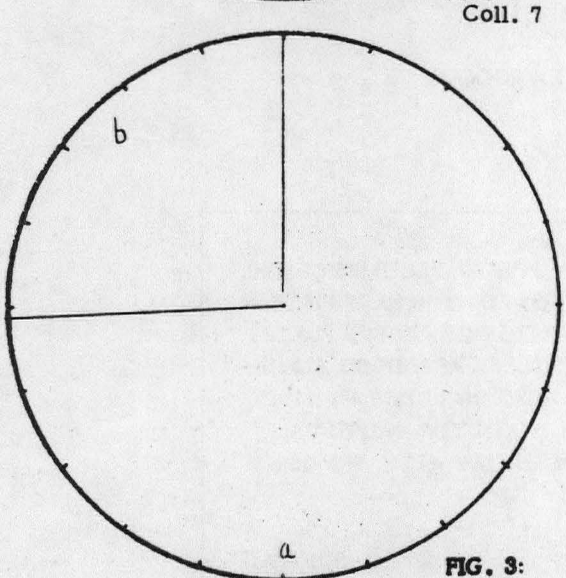


FIG. 2:
Coll. 6



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Coll. 5

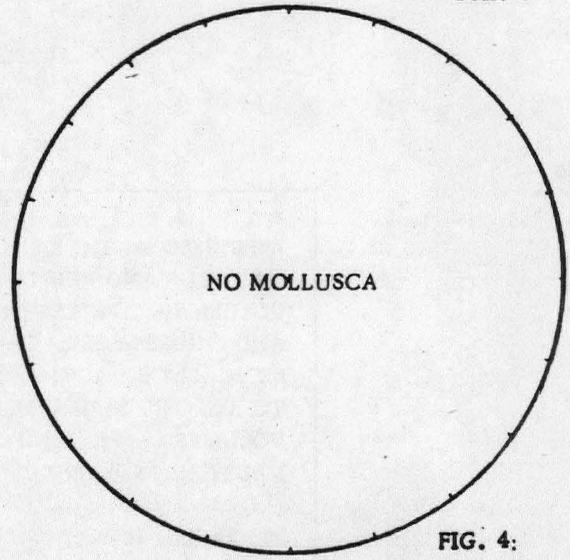

FIG. 4:
Coll. 4

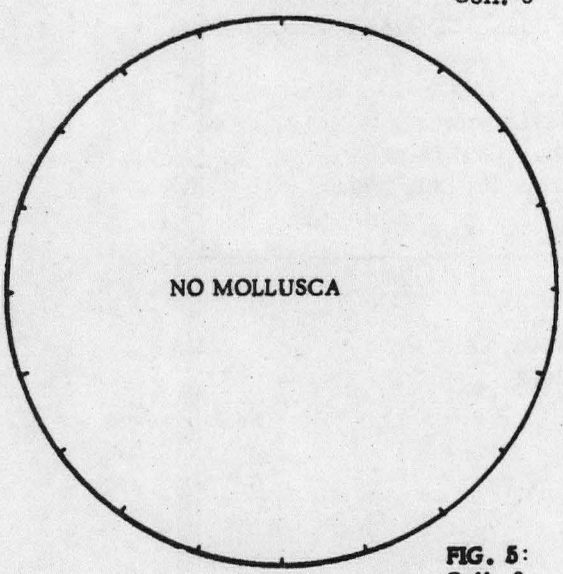

FIG. 5:
Coll. 3

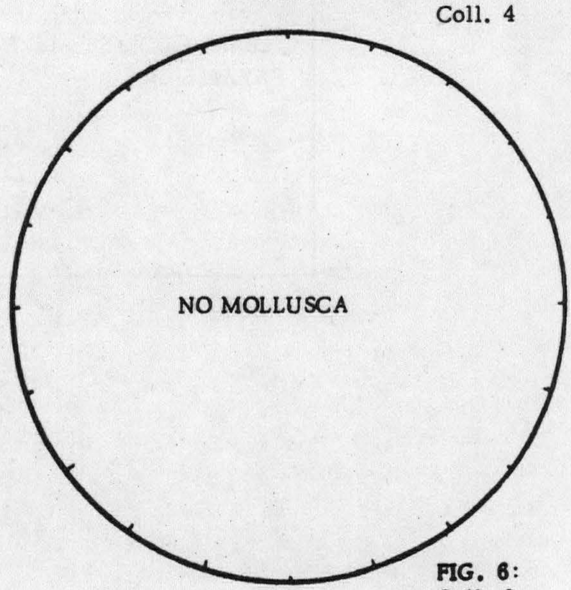

FIG. 6:
Coll. 2

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TO THE

NAUTILUS

VOLUMES 3-75 AND ITS PREDECESSOR THE

CONCHOLOGISTS' EXCHANGE

VOLUMES 1 AND 2

COMPILED BY

AURÈLE LA ROCQUE

COLUMBUS, OHIO
1963